BROOKES AUTOMOBILE HANDBOOK

The Automobile Handbook

A Manual of Practical Information for Automobile Owners, Repair Men and Schools

By

L. ELLIOTT BROOKES

Revised and Enlarged By

HAROLD P. MANLY

Author of "Automobile Starting and Lighting."

Subjects Arranged in Alphabetical Order and Indexed

FULLY ILLUSTRATED

CHICAGO
FREDERICK J. DRAKE & CO.
Publishers

PREFACE

The Automobile Handbook has been designed to afford all those interested in self-propelled vehicles a concise, complete and accurate work of reference from which may be secured, in the shortest possible time, anything from a single fact to a complete exposition of the major subjects pertaining to the motor car.

The subject matter of the *Handbook* has been arranged in alphabetical order with a careful classification and grouping under their main titles of such important subjects as Ignition, Starting and Lighting, Engines, Carburetors, Fuels, Axles, Valves and others of equal value.

Detailed treatment has been included on all subjects necessary to fully cover the automobile field, and sufficient information and description have been given to make the treatment of each subject complete, either from the standpoint of the operator or repairman.

It will be noted that all details have been treated in accordance with present day usage and that all of the important principles and types of construction of recent adoption have been covered. The underlying principles of operation, of course, remain unaltered, but their application has changed radically in a great many cases. It is for this reason that descriptions of methods of building which may be considered obsolete are omitted from the book, thus avoiding possible confusion as well as loss of time in useless study.

The reader's attention is called to the index, which is complete and lists all subjects under any of the names that might come to mind and which also gives a complete outline of the cross references and related subjects which are required to continue an investigation along any line selected.

H. P. Manly.

Chicago, March 1, 1919.

The Automobile Handbook

Acid, Battery. The liquid electrolyte of the lead-acid type of storage battery is composed of varying proportions of sulphuric acid and water. The sulphuric acid must be chemically pure and the water must be distilled or at least must not contain foreign matter. The proportion of acid is measured by the specific gravity of the mixture.

TABLE 1

Specific Gravity of Liquid	Percentage of Acid in Mixture By Volume	Percentage of Acid in Mixture By Weight	Number of Parts of Acid to Each 100 Parts of Water By Volume	Number of Parts of Acid to Each 100 Parts of Water By Weight
1.100	9.0	15.0	10	17½
1.125	11.0	18.5	12½	22½
1.150	13.4	22.0	15½	28
1.175	15.7	25.4	18½	34
1.200	18.1	28.5	22	40
1.225	20.5	32.5	25½	48½
1.250	23.0	35.5	29½	55
1.275	25.5	38.5	34	62½
1.300	28:0	42.0	39	72½

The proportions when measured by weight are always greater than by volume because the acid is nearly twice as heavy as water. See *Battery, Storage*.

Accelerator. The name given to a foot control for the carburetor throttle valve.

Accumulator. An old and now little used name for a storage battery. See *Battery, Storage.*

Air. Air consists, by weight, of oxygen 77 parts and nitrogen 23 parts; by volume, of 21 parts oxygen and 79 parts nitrogen. One pound of air at atmospheric pressure, and 70 degrees. Fahr., occupies 13.34 cubic feet of space. One cubic foot of air weighs 1 1-7 ounces.

Air Resistance, Horsepower Required to Overcome. The power required to move a plane surface, such as the vertical projection of an automobile, against the air, does not become of much importance until the car attains a speed of 10 to 12 miles per hour, when it becomes an important factor.

The horsepower required to propel an automobile against the resistance of the air may be approximately calculated by the following formula. Let V be the velocity of the car in feet per second, and A the projected area of the front of the car in square feet—this may be assumed as the height from the frame to the top of the body multiplied by the width of the seat at the floor line of the car—let H.P. be the horsepower required to overcome the air resistance, then

$$H.P. = \frac{V^3 \times A}{240{,}000}$$

To simplify the use of the above formula, Table 2 gives speeds in miles per hour corresponding to their respective velocities in feet per second and also cubes of velocities in feet per second.

TABLE 2.

CUBES OF VELOCITIES IN FEET PER SECOND.

Miles per Hour of Car.	Feet per Second.	Cube of Velocity in Ft. per Second.	Miles per Hour of Car.	Feet per Second,	Cube of Velocity in Ft. per Second,
10.2	15	3,375	34.0	50	125,000
13.6	20	8,000	40.9	60	216,000
17.2	25	15,625	47.7	70	343,000
20.4	30	27,000	54.4	80	512,000
27.2	40	64,000	61.3	90	729,000

To ascertain approximately the horsepower that will be necessary to drive a car against a wind of known velocity, the speed of the car must be added to that of the wind, and the required horsepower may be found either by use of the formula given or by reference to Table 3, which gives the horsepower per square foot of projected surface required to propel a car against the resistance of the air, with varying speeds in miles per hour or velocities in feet per minute.

TABLE 3.

HORSEPOWER REQUIRED PER SQUARE FOOT OF SURFACE, TO MOVE A CAR AGAINST AIR RESISTANCE.

Miles per Hour of Car.	Feet per Second.	Horse-power per Square Foot of Surface.	Miles per Hour of Car.	Feet per Second.	Horse-power per Square Foot of Surface.
10	14.7	0.013	40	58.7	0.84
15	22.0	0.44	50	73.3	1.64
20	24.6	0.105	60	87.9	2.83
25	36.7	0.205	80	117.3	6.72
30	44.0	0.354	100	146.6	13.12

The horsepower given by the formula and Table 3 simply refers to the additional power necessary to overcome air resistance and not to the actual power required to propel a car at a given speed; this is entirely another matter.

Alcohol. There are two kinds of alcohol; methyl, or wood, alcohol, CH_4O, and ethyl, or grain, alcohol, C_2H_6O. The former has been found objectionable for use in internal-combustion engines, because it apparently liberates acetic acid, which corrodes the cylinders and valves.

As alcohol is a fixed product, and the same the world over, it has a great advantage as a motive power over gasoline and other petroleum products. Denatured alcohol contains 4,172 heat units per pound as compared to 18,000 for gasoline, and, as its cost is higher, this fuel would not seem practicable from an economic standpoint. By mixing the alcohol, however, with a high grade of gasoline, its price is lowered, and the number of heat units per pound greatly increased. Mixtures containing 50 per cent alcohol have a calorific power of 11,086 heat units per pound, and as it has been found by numerous tests in France that it requires no more of this mixture than of gasoline to develop a certain power, its efficiency is considerably greater, reaching a value of 24 per cent as compared to 16 for the gasoline motor. In some recent experiments in France with a motor specially constructed for the use of alcohol, the consumption was lowered to 0.124 pound per horse power, using 50 per cent carburetted alcohol.

Grain, or ethyl, alcohol has a specific gravity of .795, and may be obtained by distillation from corn, wheat, and other grains, potatoes, molasses, or anything containing sugar or starch. When pure, it absorbs water rapidly from the air, more rapidly in fact than it loses its own substance by evaporation; but when diluted to the proportion of about 85 per cent. alcohol and 15 per cent. water, it evaporates practically as if it were a single liquid and not a mixture. In France, it is denatured for motor purposes by the addition of 10 liters of 90° wood alcohol, and 500 grams of heavy benzine, to 100 liters of 90° ethyl alcohol. In Germany, benzol is added to the extent of 15 per cent. for denaturing, no wood alcohol being used. In the United States the so-called "denatured" alcohol, which is that used in the arts and industries, is composed of ethyl or grain alcohol, to which have been added certain diluents calculated to make it unfit for drinking. The Internal Revenue regulations specify that to 100 volumes of ethyl alcohol there must be added 10 volumes of methyl (wood) alcohol and one-half of one volume of benzine, or to the same quantity of ethyl alcohol must be added 2 volumes of wood alcohol and one-half of one volume of pyridine bases.

As compared with gasoline as a fuel for internal-combustion motors, alcohol exhibits several striking peculiarities.

First, the combustion is much more likely to be complete. A mixture of 90° alcohol vapor and air will burn completely when the proportion varies from 1 of the vapor with 10 of air to 1 of the vapor with 25 of air, thus exhibiting a much wider range of proportions for combustibility than is the case with gasoline. As the combustion is complete, the exhaust is practically odorless, consisting only of water vapor and carbon dioxide.

Second, the inflammability of an alcohol mixture is much lower. This is due partly, no doubt, to the presence of water in the alcohol, which is vaporized with the alcohol in the engine and must be converted into steam at the expense of the combustion.

For these reasons, the compression of an alcohol mixture is carried far above that permissible with a gasoline mixture, without danger of spontaneous ignition. The rapidity of combustion of alcohol in an engine is considerably less than that of a gasoline mixture, and for this reason the speed of alcohol engines must be somewhat slow.

The facts that alcohol of sufficient purity for use in engines can be produced from the waste products of many of the country's industries, and at a nominal cost, and that many thousands of acres of land, unfit for the cultivation of first-class grain, etc., may be utilized for the production of vegetable matter rich in the elements which form alcohol upon fermentation, lead to the supposition that within a few years, or as soon as there is a sufficient demand for alcohol to warrant the erection of special distilleries, it may be purchased at such a low price that it will not only be commercially possible, but will in a measure force gasoline and other petroleum distillates from the field.

A carbureter designed to operate with alcohol can always be used with gasoline, but the reverse conditions are not true, that is, a gasoline carbureter will not operate successfully with alcohol, except in some rare instances. Alcohol evaporates slower than gasoline and its time of combustion is much slower, but it maintains its mean effective explosion pressure far better than gasoline.

Explosive motors fitted with alcohol carbureters make far less noise than when using gasoline as a fuel, due to the slower burning of the explosive charge, they also make less smoke and smell.

The jet or spray of a float-feed carbureter will have to pass nearly 40 per cent. more liquid fuel than when using gasoline, consequently the opening in the nozzle must be proportionally larger.

A carbureter using alcohol must be fitted with some form of device to heat the alcohol to ensure rapid evaporation—this is usually done by surrounding the mixing-chamber with an exhaust-heated jacket.

The same quantity of alcohol will only take a car two-thirds of the distance that gasoline will, hence greater storage capacity would be needed on a car using alcohol as a fuel.

An explosive motor designed to use alcohol requires a greater degree of compression than a motor of the same bore and stroke designed to use gasoline, in order to develop the same power.

Alloys. In the following pages are given the compositions of the principal alloys (except *Steel,* which see) as recommended by the Society of Automotive Engineers.

Aluminum.—Where a tough, light alloy, possessing a high degree of strength combined with great lightness is desired the composition can be 90.0% aluminum and 7.0 to 8.5% copper.

An alloy possessing strength, closeness of grain and freedom from blowholes in casting is composed of 84% tin, 9% antimony and zinc, 2.0 to 3.0% copper and not to exceed 0.4% of manganese.

Bearing Metals.—A babbit metal suitable for the connecting rod linings of motor bearings or for any service of severe operating conditions is composed of 84% tin, 9% antimony and 7% copper.

A white brass for use in engines is made from 65% tin, 28 to 30% zinc and 3 to 6% copper.

Phosphor bronze is a composition having good anti-friction qualities combined with the ability to stand up under heavy loads and hard usage. It is used against hardened steel. The composition consists of 80% copper, 10% tin and 10% lead.

Brass and Bronze.—Red brass, suitable for light bearings and castings and having good machining qualities is composed of 85% copper, 5% tin, 5% lead and 5% zinc.

Yellow brass for general brass casting work consists of 62 to 65% copper, 36 to 31% zinc and 2% to 4% lead.

A hard cast bronze suitable for severe working conditions under heavy pressures and high speeds, also for light gears, valves, etc., is composed of 87 to 88% copper, 9.5 to 10.5% tin and 1.5 to 2.5% zinc.

Gear bronze, for use in severe service and where quiet running is required, consists of 88 to 89% copper, 11 to 12% tin and 0.15 to 0.30% phosphorous. This bronze is generally used in gears and worms.

Manganese bronze is understood to mean a metal constituted principally of copper and zinc in the approximate proportion of 60 and 40, small quantities of iron and variable quantities of manganese being present. This metal is used in castings where strength and toughness are required. It has a tensile strength of 60,000 pounds per square inch.

Aluminum alloys are commonly used in automobile construction, these including the various grades known by the name aluminum, also aluminum bronze which contains a considerable percentage of copper and has been used similarly to manganese bronze. Magnalium is an aluminum alloy containing magnesium. It is lighter than aluminum and has greater strength. It is used for pistons.

Brass of all kinds has copper for its base and zinc as its principal alloy. All bronzes have copper as the base and tin as the principal alloy. Gun metal is a bronze. Manganese bronze is in reality a form of brass. Tobin bronze, Delta metal, Tensilite, etc., are special alloys manufactured under these trade names by certain makers. Monel metal is a natural alloy of copper and nickel which is mined and refined without changing the proportions.

Alternating Current, Use of. It is not only useless but absolutely injurious to attempt to charge a storage battery directly from an alternating current circuit. This can only be done by means of a rotary converter, which is in reality a motor-generator, receiving its power from the alternating current and transforming it into a direct current which can be used to charge the batteries.

Aluminum. A soft ductile malleable metal, of a white color, approaching silver, but with a bluish cast. Very non-corrosive. Tenacity about one-third that of wrought iron. Specific gravity 2.6. Atomic weight 27.1. It is the lightest of all the useful metals, with the exception of magnesium.

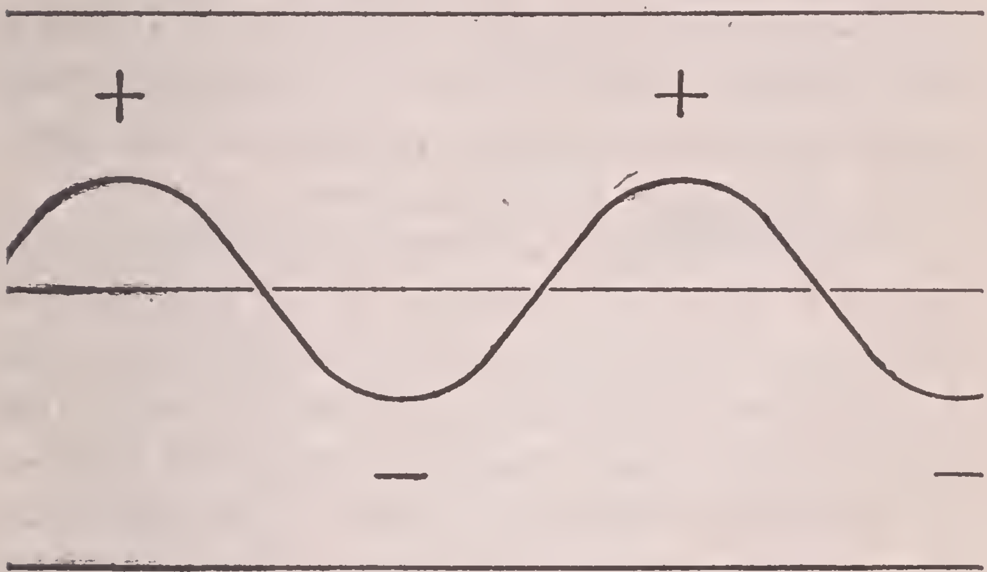


Fig. 1
Alternating Current Wave

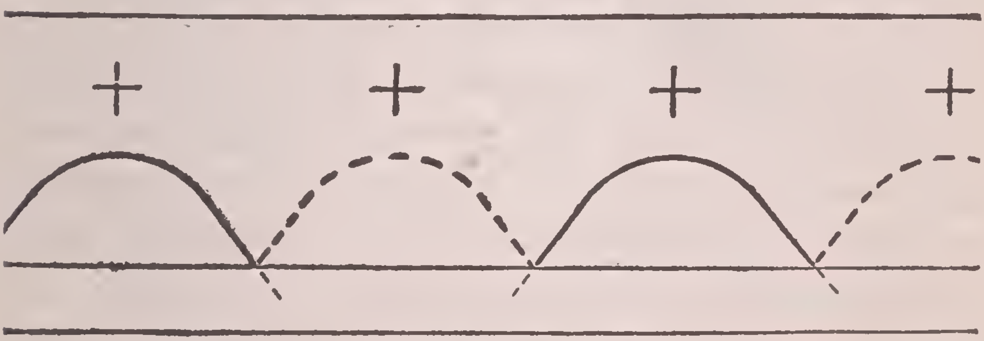


Fig. 2
Direct Current Impulses

Aluminum Solder. The following formula is for a solder which will work equally well with aluminum or aluminoid: Tin, 10 parts—cadmium, 10 parts—zinc, 10 parts—lead, 1 part. The pieces to be soldered must be thoroughly cleansed and then put in a bath of a strong solution of hyposulphate of soda for about two hours before soldering.

Ammeter, Use of. Ammeters are quite generally used in connection with electric starting and lighting systems, either as a permanent part of the equipment, or as an attachment used during the process of trouble location.

When possible the ammeter should be so connected that it will measure all of the current flowing into the battery from the generator and so that it will measure all current leaving the battery except that used for starting the engine. An ammeter sufficiently great in capacity to measure the heavy flow during the cranking operation would not accurately measure the comparatively small currents used for charging and lighting. It is therefore necessary to find a wire on the equipment that carries all of the charging current and all of the current for lighting and accessories, but which does not carry starting current. This attachment may usually be made by following one of the large cables from the battery until a smaller line branches from this cable at some terminal or junction. The ammeter should then be attached in this smaller line and as close to the large battery cable as is possible.

Should the charging wires and the lighting wires be connected at different points, it will not be possible to make a single connection of the ammeter without changing the wiring. This is also the case with many motor-dynamo systems in which no exposed line can be selected which carries only charging and lighting current.

Ammeter, Construction of. Ammeters for automobile use are constructed on the principle

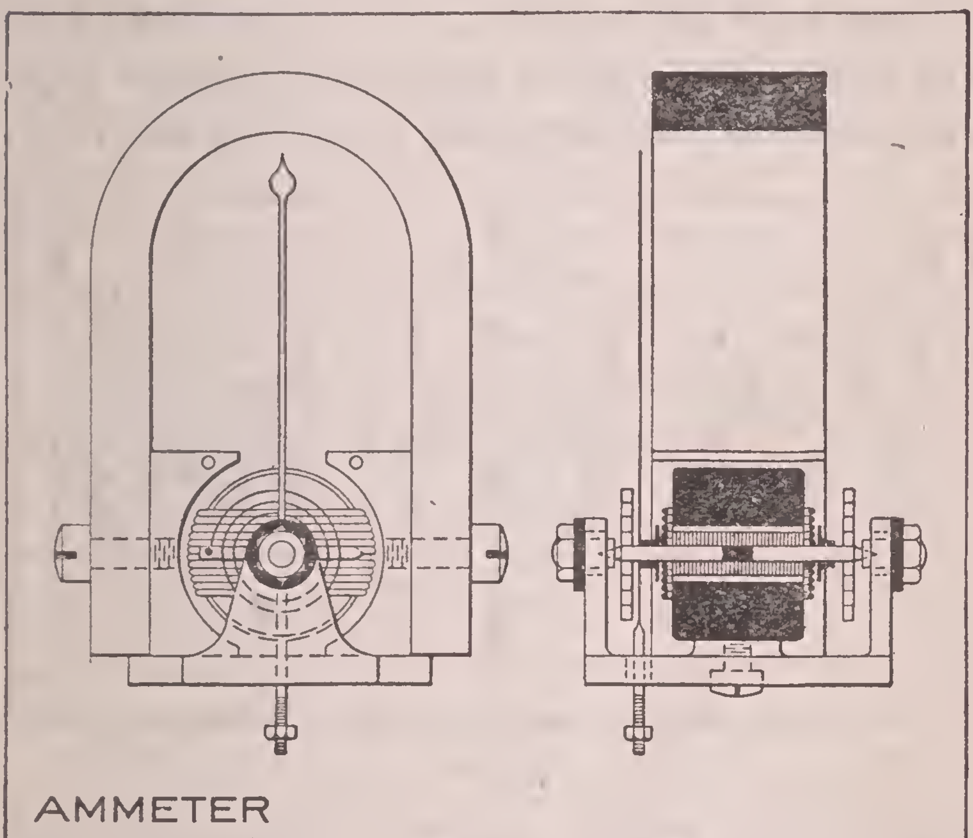


Fig. 3

of the D'Arsonval galvanometer with a permanent magnetic field. The special feature is a small oscillating coil mounted on cone-point bearings surrounding a stationary armature which is centrally located between the pole-pieces of a permanent magnet, with a pointer or index-finger which indicates the electrical variations on a graduated scale.

The construction of an ammeter is fully show in the two views in Figure 3. The permanent magnets used in its construction are of a special quality of hardened steel, made only for this purpose and possessed of great magnetic permeability. The pole-pieces, which are of soft steel and well annealed, are attached to the inside of the lower part of the magnet legs, the joints between the pole pieces and the magnet legs are usually ground to insure the full efficiency of the magnetic circuit. The soft iron core of the coil is for the purpose of rendering uniform the magnetic field in which the coil must oscillate. A coil of insulated wire is wound upon the stationary armature at right angles to its axis, in the same manner that thread is wound upon a spool, and is short-circuited on itself, that is to say, the ends of the wire forming the coil are connected together. This coil of wire is for the purpose of choking

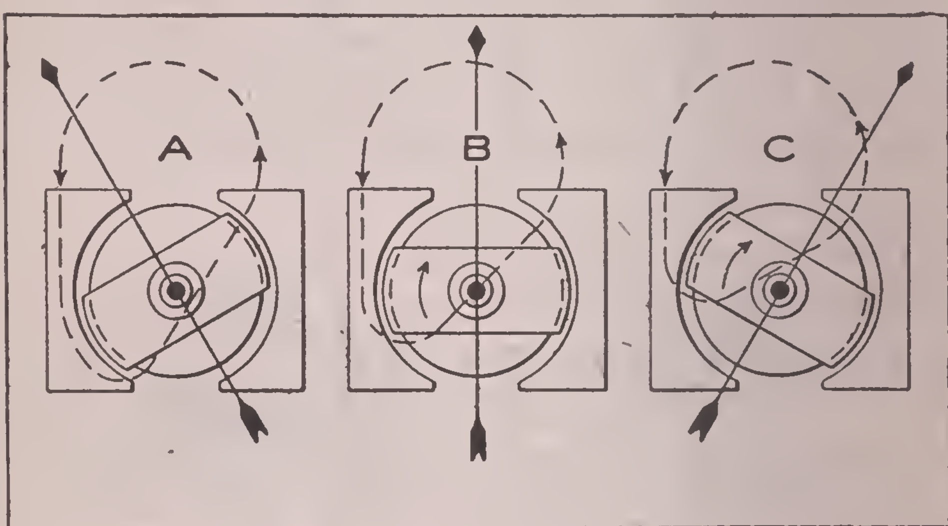


Fig. 4

the magnetism induced in the stationary armature by the oscillating coil, as it generates what are known as eddy currents within itself, thus making the instrument periodic, or dead-beat, in its indications. Around the armature core and outside the short-circuited coil of wire is wound the active or oscillating coil and at right angles to the direction of the winding of the first coil. The oscillating coil consists of a number of turns of fine insulated copper wire, to which the current is conveyed through the medium of the controlling springs at each end of the spindle, which is in two parts and connected together by a suitable sleeve of insulating material, as shown.

The pointer or index-finger is made with a boss or hub to go over the end of the spindle of the active coil and also has an extension with a small counterweight or balance, so that the pointer may be accurately adjusted.

The only difference in the construction of a voltmeter and an ammeter is that in the former the active or oscillating coil is in series with a high resistance, while in the latter it is connected across the terminals of a shunt-block. The voltmeter is in reality an ammeter, the resistance serving to keep the amperage in step with the voltage.

Reference to the three views, marked respectively A, B and C in Figure 4, will show clearly the principle of the operation of an ammeter or voltmeter, and the reason that they record the current strength or pressure of an electric current accurately.

Ammeters are of two kinds, the double-beat type, as shown in Figure 3, which indicates the current strength or number of amperes flowing in the electric circuit, without any regard to the polarity of the terminals of the circuit, by the pointer or index-finger moving either to the right or to the left of the zero position. The

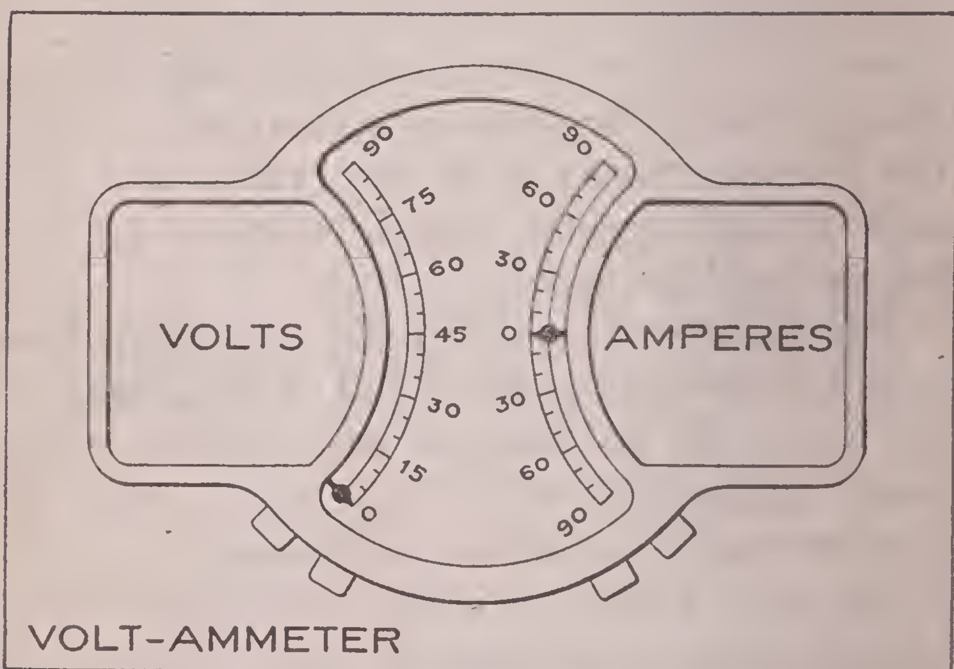


Fig. 5

single-beat type of ammeter only records in one direction, by the pointer moving from the left to the right of the graduated scale of the instrument, consequently the polarity of the terminals of this type of ammeter are marked on its outer casing and the polarity of the terminals of the electric circuit must consequently be determined before connecting them with the ammeter.

Ampere. The unit of electric current flow. An ampere is that volume of current which would pass through a circuit that offered a resistance of one ohm, under an electromotive force of one volt.

Ampere-hour, Definition of. The term ampere-hour is used to denote the capacity of a storage or a closed-circuit primary battery for current. A storage battery that will keep a 2 ampere lamp burning for 8 hours is said to have a 16 ampere-hour capacity. In a similar manner an 80 ampere-hour battery would operate the same lamp 40 hours. The voltage of a battery does not enter into the calculation of its ampere-hour capacity.

Annealing. A process of heating by means of which metals are relieved of internal strains and distortions. In some cases annealing is employed only to relieve strains, while in other cases it is desired to soften the metal sufficiently to allow its working.

Steel to be annealed is first heated to a dull red, the temperature being increased slowly so that all parts of the piece will have time to reach the same temperature at very nearly the same time. This heating is usually done in some form of oven by which the work is protected against air currents.

The work may be withdrawn from the fire or oven after reaching the desired temperature and allowed to cool in the air until no red can be seen when held in a dark place. If, upon touching a pine stick to the steel, the wood does not smoke, the cooling may be completed in a water bath.

Better results will be secured if the cooling time is extended by placing the work in a bed of ashes, charred bone, asbestos fibre, lime, sand or fire clay. The steel should be well covered with the heat retaining material and allowed to remain until cool. The greater the length of time between red heat and final coolness, the better will be the results of the annealing.

While steel is annealed by heating and cooling slowly; copper or brass is annealed by bringing to a very low red heat and then cooling quickly by plunging into cold water.

Armatures, Dynamo. The armature, or revolving member of lighting dynamos, is composed of a core made from wrought iron or mild steel. It is customary to make this core by assembling a sufficient number of thin plates made in the form of the cross section of the core, these plates being covered with an insulating composition and then fastened together on the shaft. This construction prevents the formation of harmful "eddy currents" within the metal.

The assembled core has a number of slots running lengthwise of its body and in these slots are placed the armature coils or winding of insulated wire. The coils are then connected to a commutator mounted on one end of the shaft in such a way that the current generated may be collected by the brushes.

Armatures, Slotted and Shuttle Types of. An armature is the rotating part of a dynamo or electric motor which generates electricity or develops power.

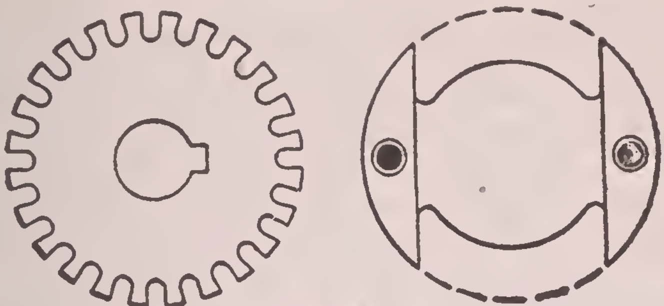


Fig. 6

The armature shown at right of Fig. 6 is known as the Siemen's H or shuttle type and is the simplest form of wire-wound armature known. The current given by this form of armature is of the alternating type and is converted into a direct-current, when desired, by means of a two-part commutator on the armature shaft.

The slotted type of armature shown at the left of Fig. 6 has a more intricate system of winding than the shuttle type just described. It has, however, a far greater electrical efficiency and gives off a steadier current than the shuttle type. It is the form most generally used for automobile and street railway motors. Like the shuttle type of armature, the current generated by the slotted type of armature is alternating, and is converted into a direct current by means of a commutator of very complicated form.

Automobile. An automobile is composed of five parts, these including; first the power plant, second the transmission system, third the running gear, fourth the control parts and fifth the body.

The power plant comprises the engine together with the parts required in order that the engine may generate power. The engine auxiliaries are: an oiling system for lubricating the moving parts, a cooling system for maintaining a temperature of the engine cylinders at which lubrication may be secured, a fuel system by means of which the engine is furnished with a combustible gas, and an ignition system which causes an electric spark and ignites the fuel.

The transmission system includes all of the parts which carry power from the engine to the driving wheels. These parts include the clutch by means of which the engine may be allowed to run with the car idle, a change speed gear which provides different ratios of relative speed between engine and driving wheels and also a reverse motion of the car, a differential for allowing one rear wheel to turn faster than the other, and a driving axle.

The running gear includes all of the parts which support the power plant, transmission system control parts and body. It consists of the axles, wheels, tires, springs and the frame with its brackets.

Axle, Front. So far it has not been found practical to combine the tractive and steering functions of an Automobile in one set of wheels and axle. Therefore it is necessary to use a rigid front axle with knuckle jointed spindles, for steering purposes, and utilize the tractive power of the rear wheels only to propel the car. Some of the earlier forms of steering axles had the wheel pivots inclined so as to bring the projection of the pivot axis in line with the point of contact of the wheel with the ground, but as such constructions have not proved satisfactory they have in most cases been abandoned.

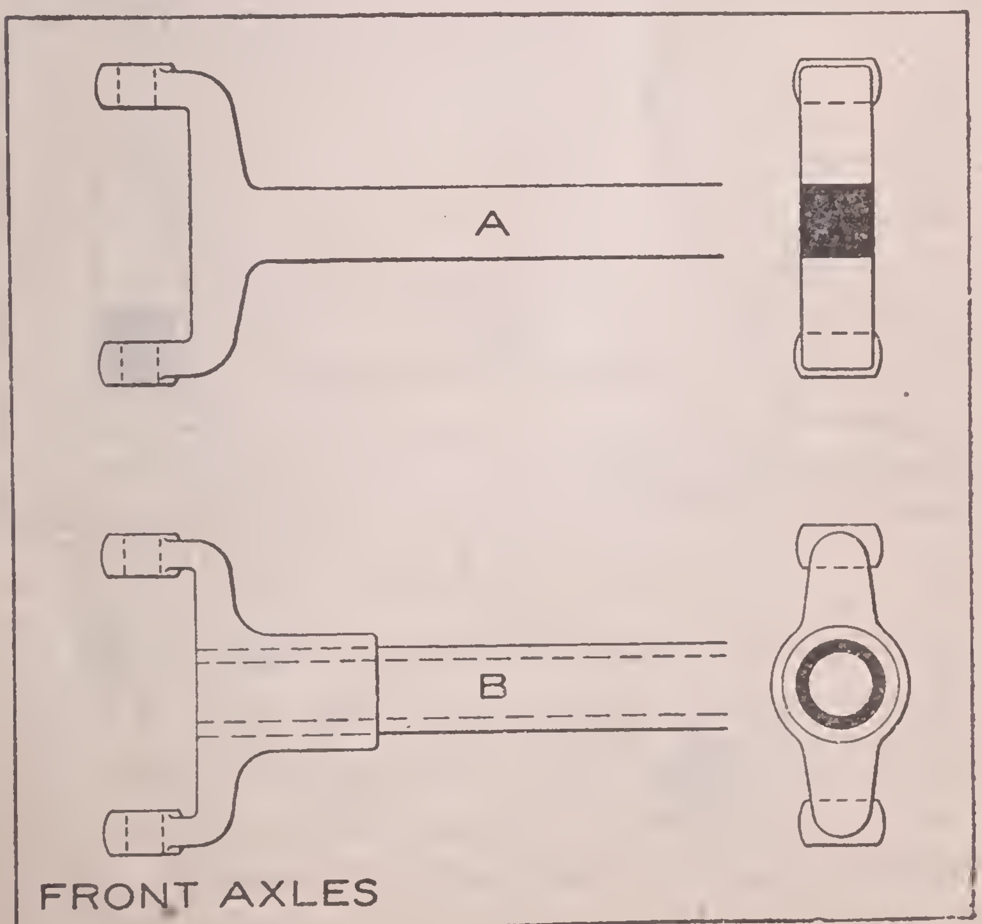


Fig. 7

In Figures 7 and 8 are illustrated four styles of front axles with steering-pivot ends: A shows a solid axle of square section, with the steering-pivot jaws and axle proper, of a single forging—B represents an axle of tubular cross-section with the steering-pivot jaws bored

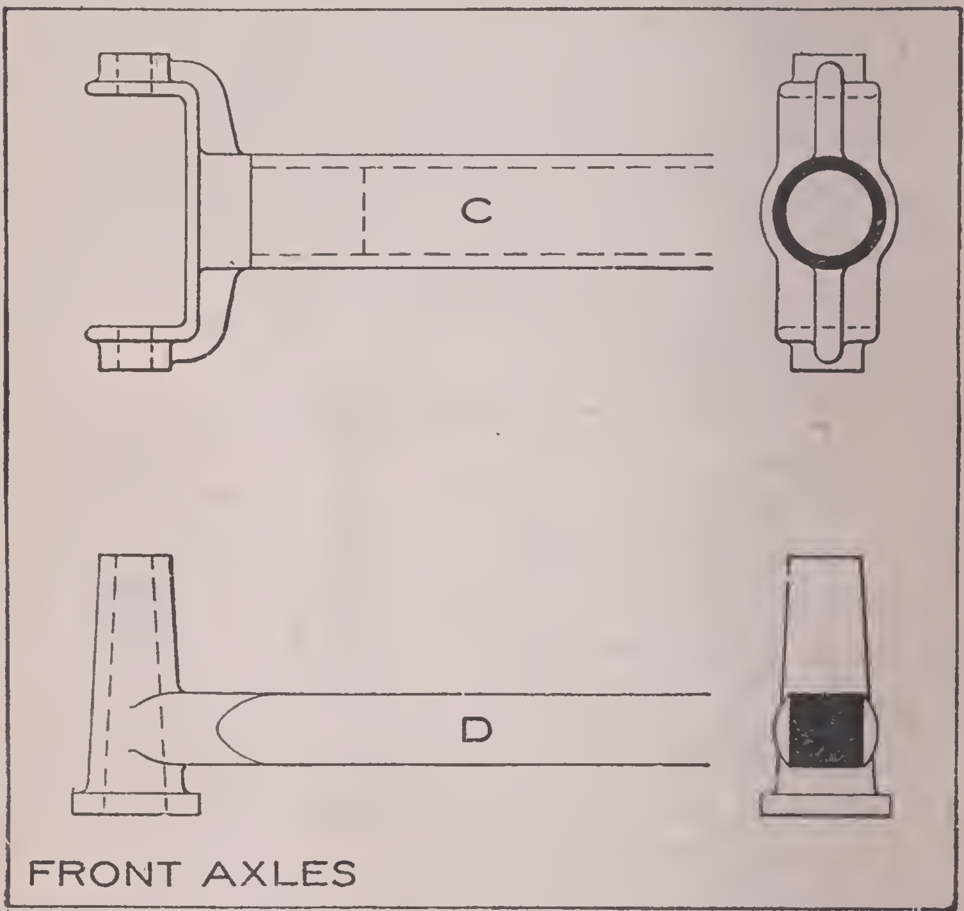


Fig. 8

out to receive the tubular axle which is firmly brazed therein—C shows another style of tubular axle, in which the steering-pivot jaw ends are turned down to fit the inside diameter of the tube and are also brazed in position, while D illustrates a one-piece axle with vertical hubs

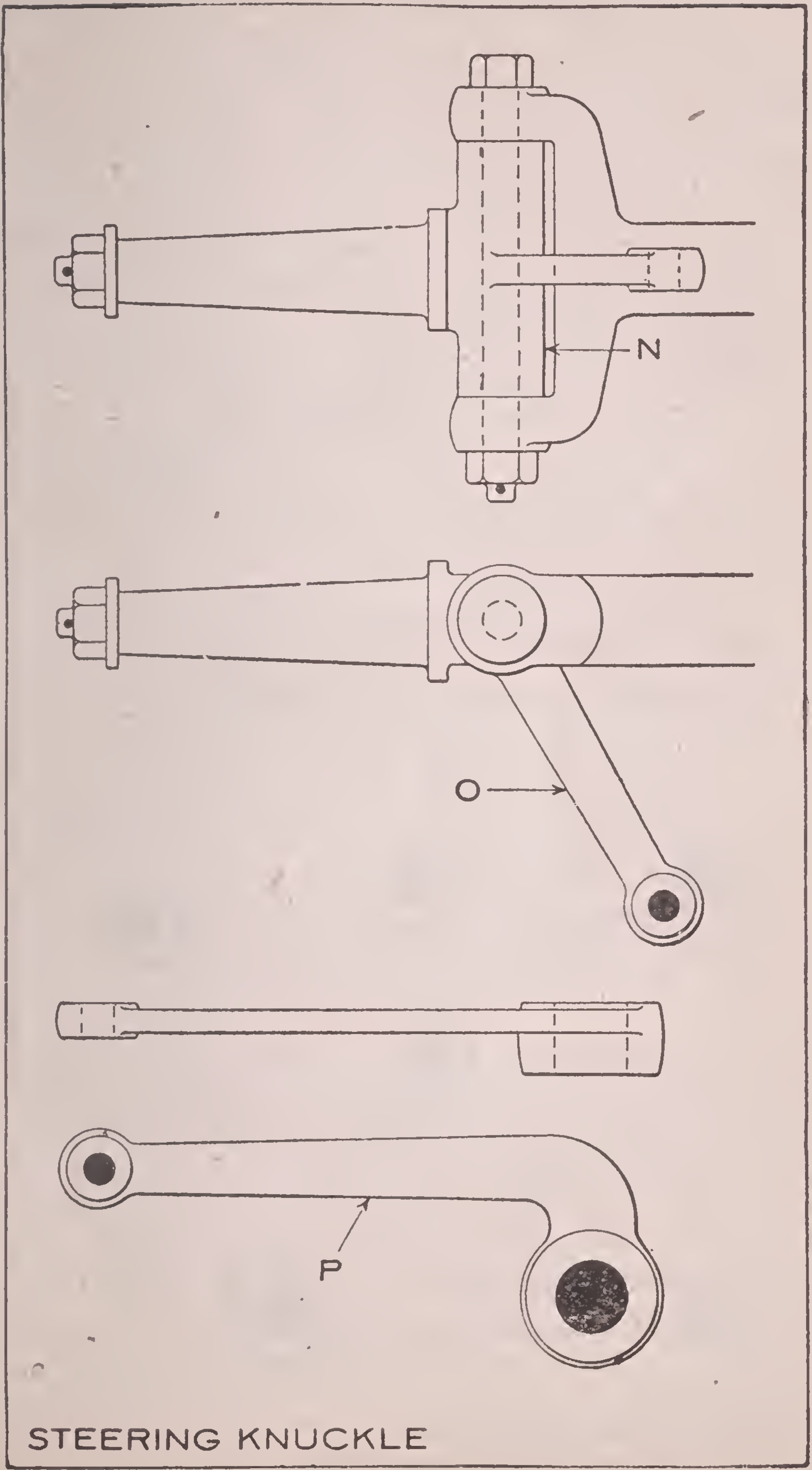


Fig. 9

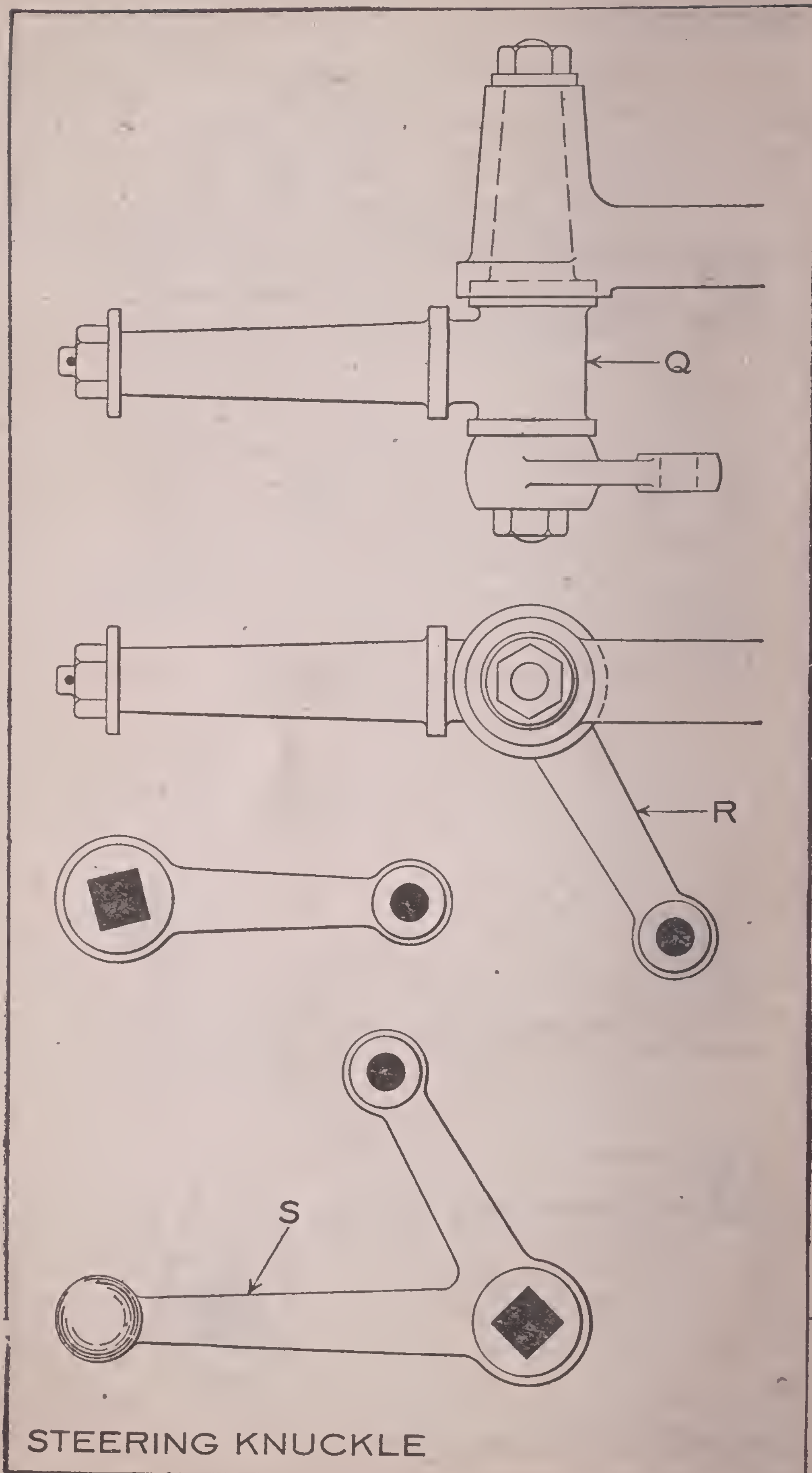


Fig. 10

instead of jaws, which carry L-shaped steering pivots, instead of the usual form of knuckles.

STEERING KNUCKLES. In order to obtain ease of operation and secure the shortest turning radius with the least movement of the steering wheel or lever, the knuckle of the steering pivot should be as close to the center of the wheel as is possible. It is also of great importance that the steering knuckles should be as heavy as is practically consistent with the size and weight of the car for which they are intended. If this imporant point be neglected, rapid wear and probable fracture of the knuckles may be looked for.

A steering knuckle with a spindle and pivot of T shape is shown in Figure 9. The spindle and pivot N and the steering arms O are usually a one-piece forging. The steering arms O are connected by means of a suitable distance rod and the steering lever P is attached to one of the pivots N by turning a shoulder upon it and pinning and brazing the steering lever and pivot hub together.

Figure 10 shows a steering knuckle with spindle and pivot of L shape. The steering arm R goes on the lower end of one pivot Q only, the other pivot having the combined steering arm and ever S on its lower end. The steering arms being detachable, the device may be operated from the right or left hand side by simply exchanging the levers R and S. The steering lever S has a ball upon its outer end to fit in the

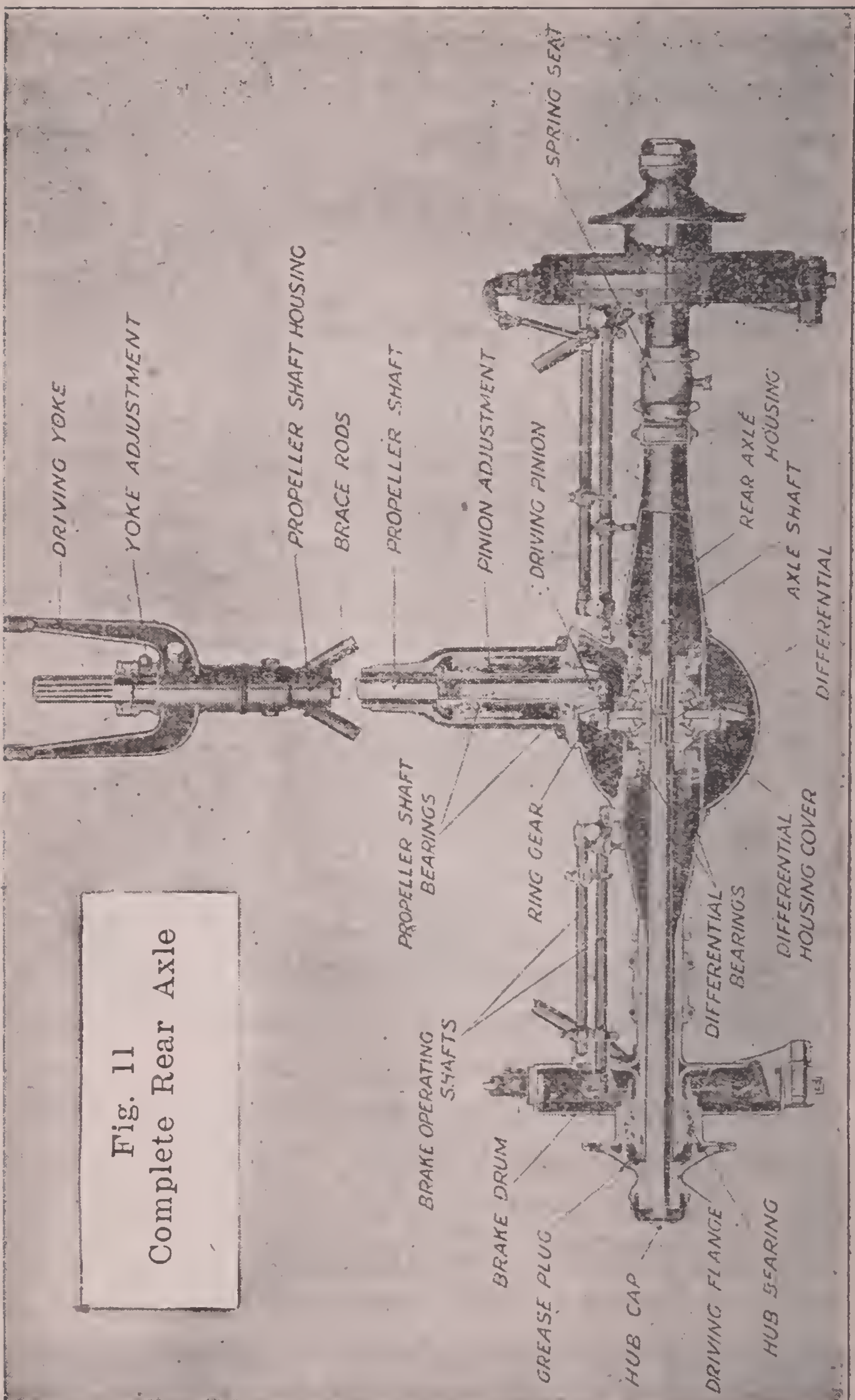


Fig. 11
Complete Rear Axle

socket on the connecting rod of the steering mechanism.

Axles, Rear. The following definitions apply to the forms of rear axles that are now and have been in use on shaft-drive cars.

A "live axle" (no longer used) is one in which the driving member is carried by a bearing at each end, the outer end carries the wheel and the inner end the differential.

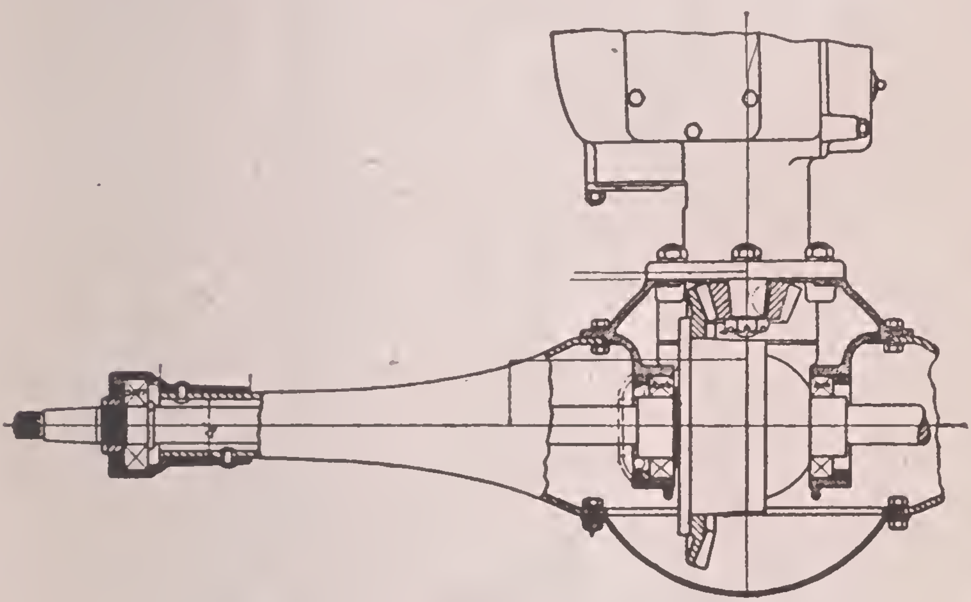


Fig. 12
Semi-Floating Rear Axle

A "semi-floating axle," Fig. 12, is one in which the driving member is carried on one bearing at its outer end and with the inner end supported by the differential. The outer end carries the wheel.

A "three-quarter floating axle," Fig. 13, is one in which the driving member is carried by the differential at its inner end and at the outer end is carried by the hub flange, the flange itself being bolted to the wheel. The wheel is then carried by a bearing that runs on the outside of the end of the axle housing tube.

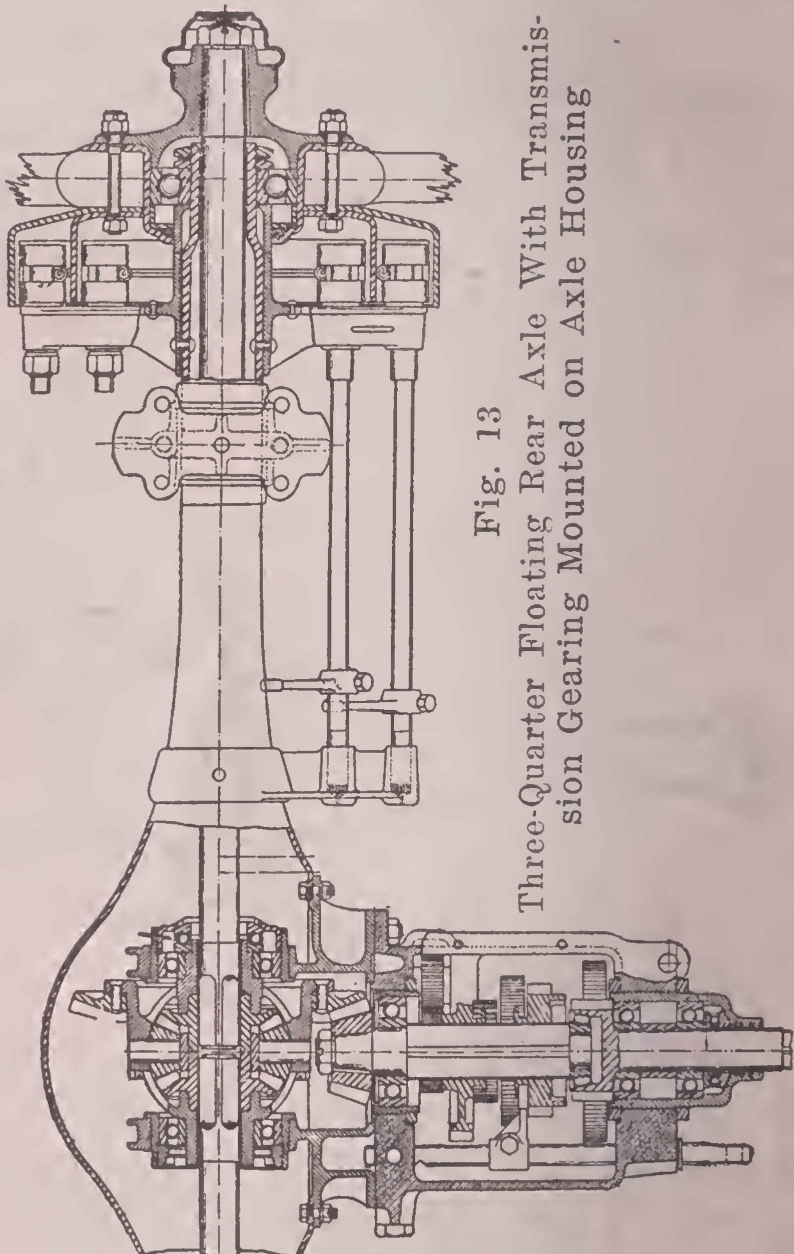


Fig. 13
Three-Quarter Floating Rear Axle With Transmission Gearing Mounted on Axle Housing

A "full floating axle," Fig. 14, is one in which the driving member is carried by the differential at its inner end and at the outer end is carried by a jaw clutch, the clutch itself being engaged with and meshing with the wheel hub. The wheel is then carried on two bearings that run on the outside of the axle housing tube. With

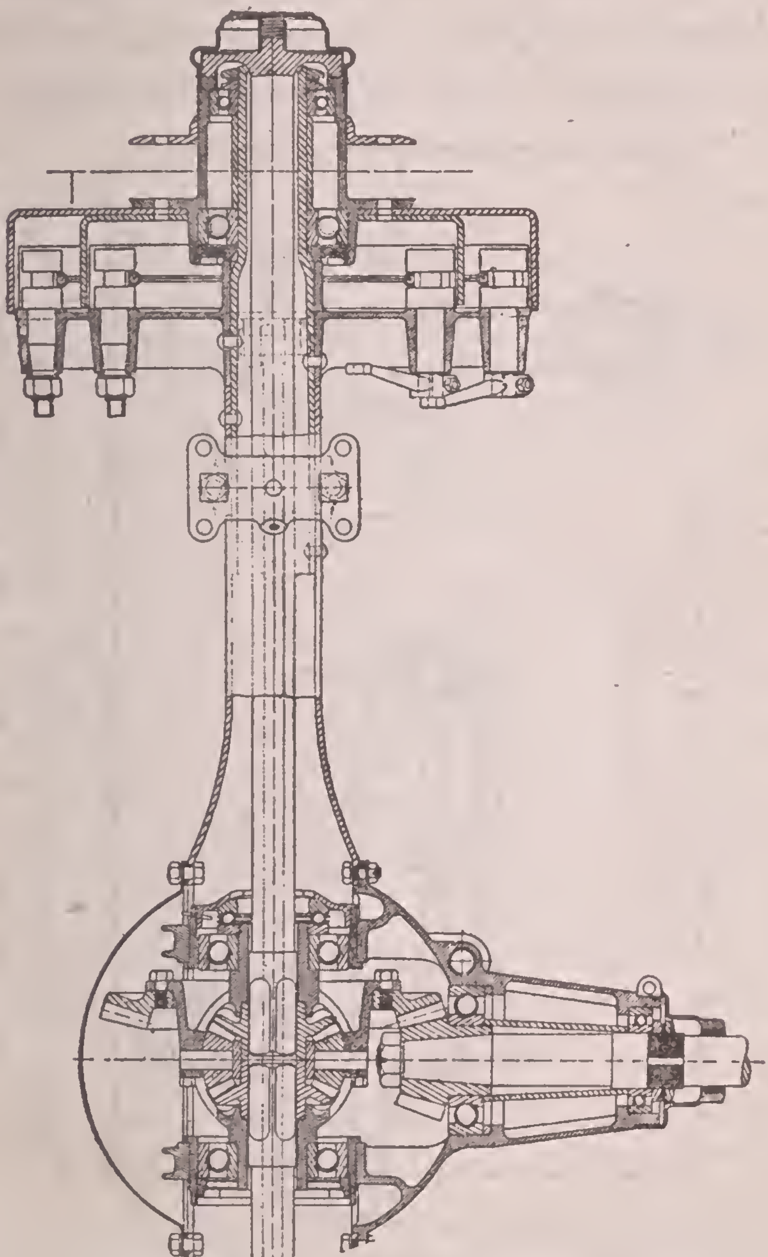


Fig. 14
Full-Floating Rear Axle With Annular Ball Bearings

this construction, the drive shaft may be entirely withdrawn from the car without disturbing the wheel or other axle parts.

In this case the tube is reduced in diameter to take the bearings, and the shoulder so formed is taken advantage of in the process of providing for thrust. The shaft has no work to do excepting to take torsional moments, and

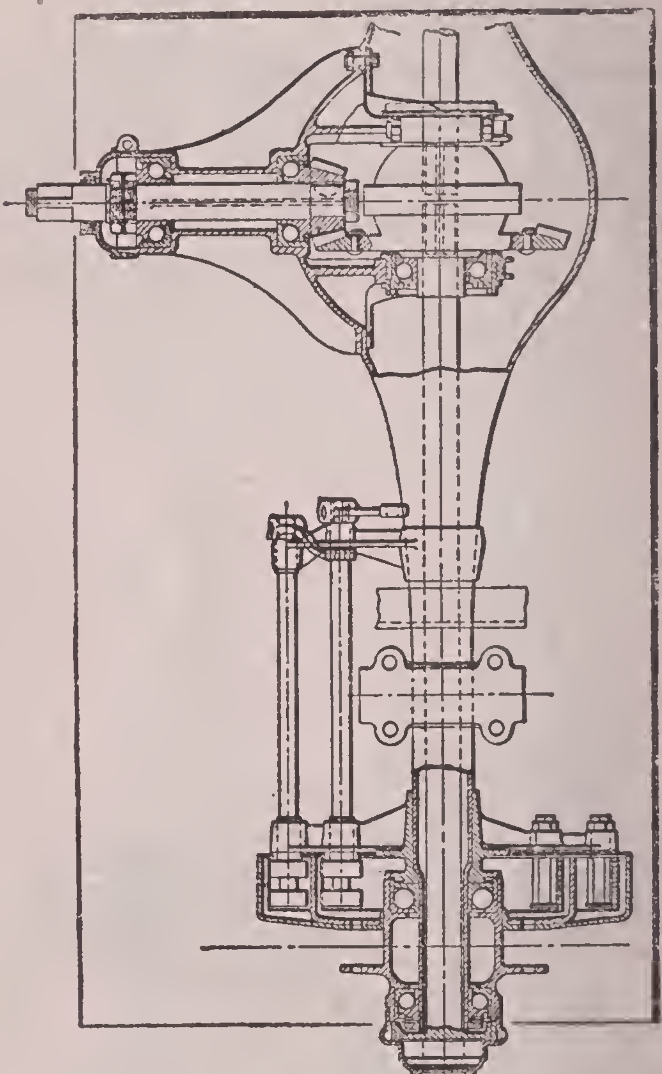


Fig. 15
McCord Full Floating Live Rear Axle With Annular Type Ball Bearings and Parts of Drop Forged Steel

the design throughout includes drop forgings of steel and drawn-steel parts. The inner race of the ball bearings is a sufficiently heavy tube, but it is not shaped in such a way as to act as a "preventer bearing," hence complete dependence is placed on the ball bearings and they are made large enough to take the responsibility.

Axle, Rear, Three-Quarters Floating. In this design, Fig. 13, the axle housing is extended outward to a point in line with the outside surface of the wheel, and the outer end is made of a diameter just large enough to allow the axle shaft to pass through it. Mounted on the outer end of the axle and directly in the center of the wheel is a single bearing, usually of the annular ball type. The wheel spokes are mounted in the hub flange in the usual manner and the flange is carried upon the outer surface of the bearing mentioned above. A large hub forging is bolted to the wheel flange and the bolts pass through the spokes which hold the brake drum on the inside. The outer end of the driving shaft is fastened into this hub forging by a key way and taper; the inner end of the driving shaft is carried by the differential in the same manner as with a full floating type. It will therefore be seen that the radial load of the wheel is carried on the single bearing at the end of the housing, and this bearing is also required to carry the end thrust. The binding strains that are imposed upon the wheel when turning corners, for instance, are provided for through the rigidity of the driving shaft, which is fastened solidly into the wheel hub at its outer end and which is carried by the differential at its inner end. This gives a leverage equal in length to the distance between the outer bearing and point of support in the differential.

Axle, Rear, Internal Gear. The internal gear type of rear axle as used on commercial cars

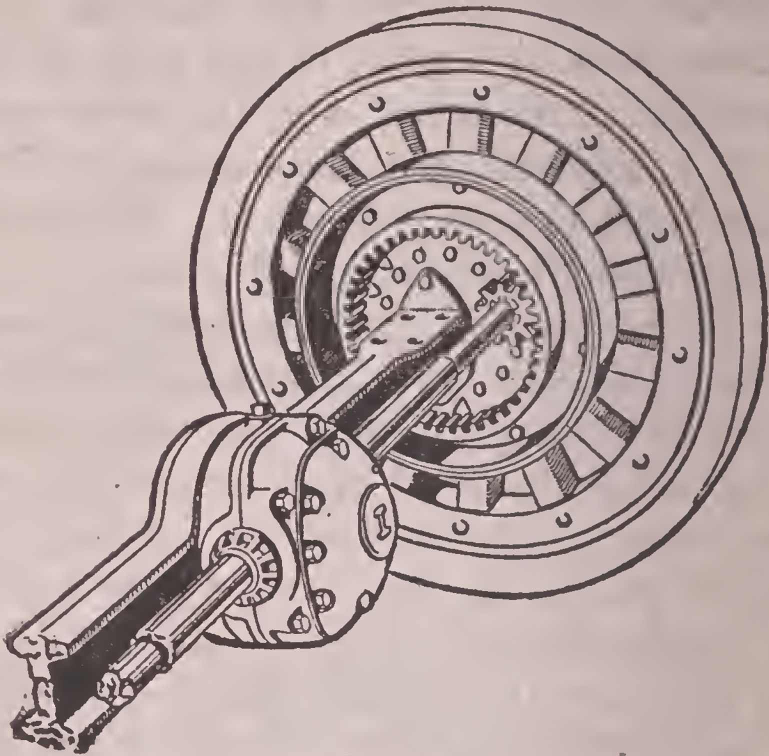


Fig. 16
Principle of Internal Gear Axle

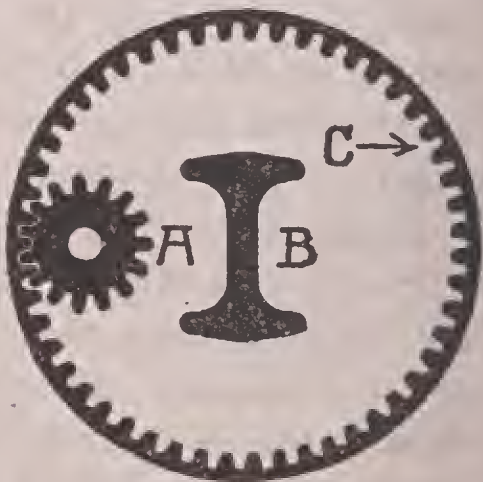


Fig. 17
Internal Gear Drive

consists of two principal parts, one being a load carrying member consisting either of an "I" beam or tubular member on which the springs and road wheels are mounted, and the other being a driving member which is much like the ordinary bevel gear type of rear axle with the exception that the outer ends of its shafts are fitted with spur gears which drive internally toothed ring gears, these ring gears being in turn fixed to the driving wheels of the car. The

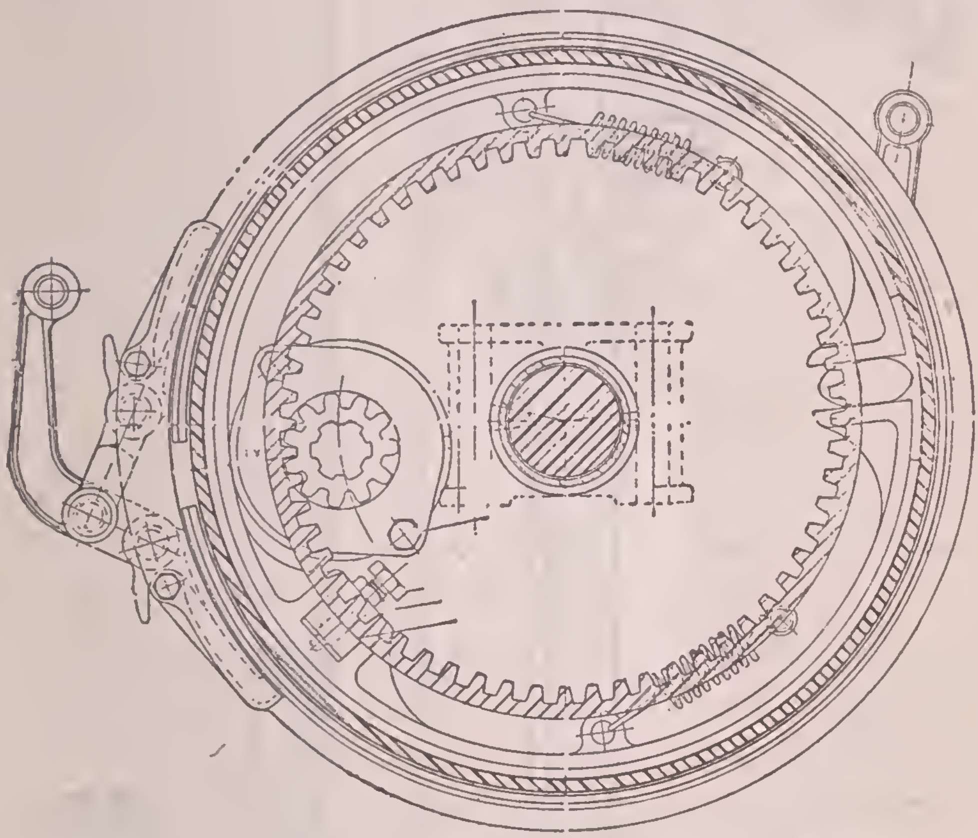


Fig. 18
Details of Internal Gear Drive

principle of such an axle is shown in Figure 16 which illustrates the application of the gearing.

The relation of the driving parts is shown in Figure 17, A being the small spur gear carried by the ends of the driving shafts, B the load carrying member and C the internal gear fixed to the wheel. Depending on the position of

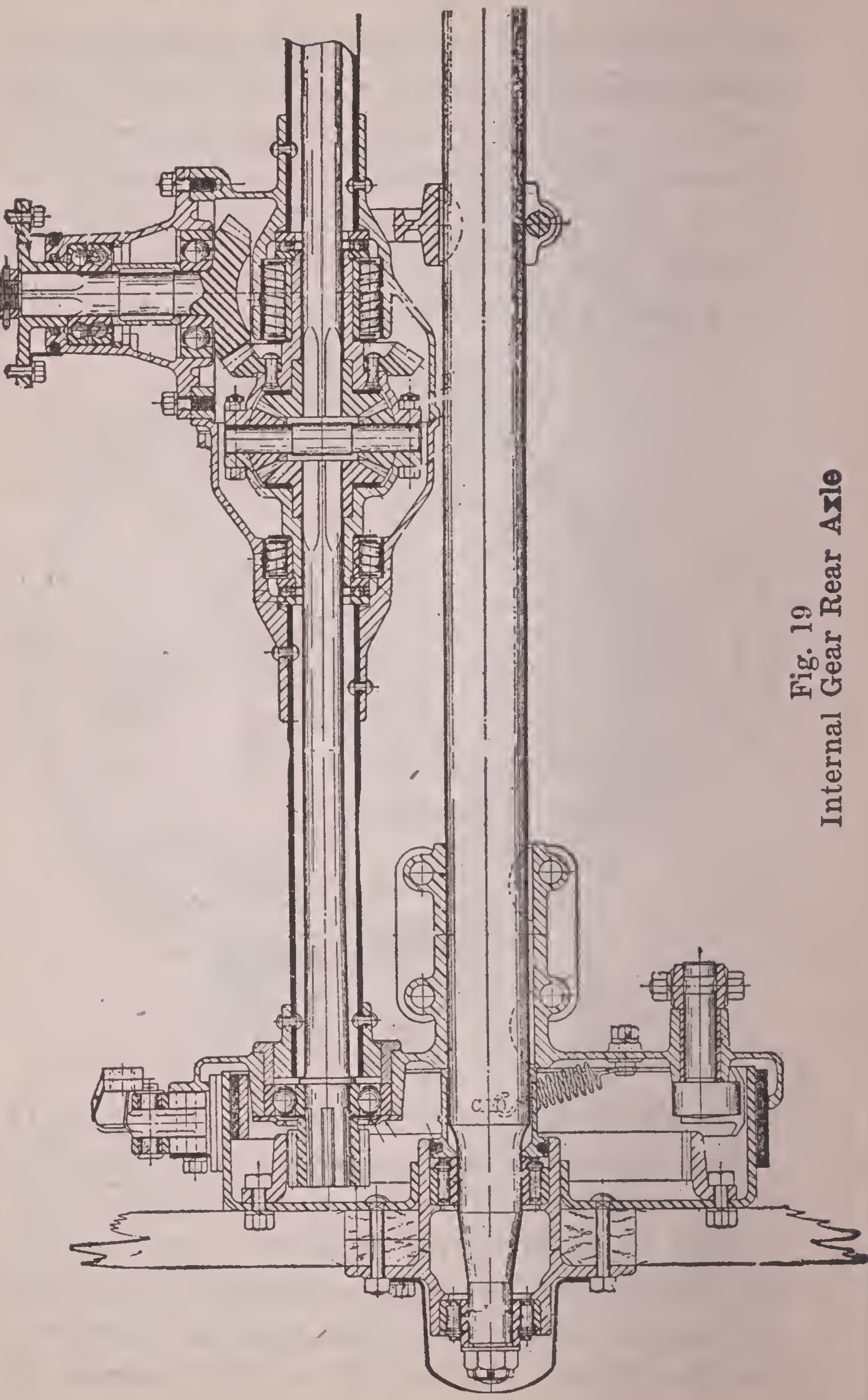


Fig. 19
Internal Gear Rear Axle

the driving member, ahead of or behind the load carrier, the spur gear A will be ahead of or behind the load member. Details of the construction at the wheel are shown in Figure 18 which illustrates a type of axle (Russell) having the driving member in front of the load carrying tubular axle. It will be noted from this illustration that a comparatively great gear reduction is secured between the spur gear and the internal gear, leaving a much smaller reduction to be obtained between the bevel gears at the center of the driving member than would be the case with any form of single reduction employing spur or bevel gears.

In Figure 19 is shown a plan view of the axle having the driving unit ahead of the load carrier. The comparative size of the bevel pinion and gear in the differential housing indicates the small reduction at this point.

Figure 20 shows the construction of an internal gear axle having the live axle back of the "I" beam load carrying member (Torbensen). In this case the small spur gear meshes with the internal gear at the rear side.

Because of the greater part of the reduction being obtained at the wheel, the driving shafts in internal gear axles are lighter than the corresponding parts in single reduction axles and in general, for a given load carrying capacity, these axles are found to be comparatively light in weight. This advantage is in part balanced by the increase in the number of gears, bearings and related parts.

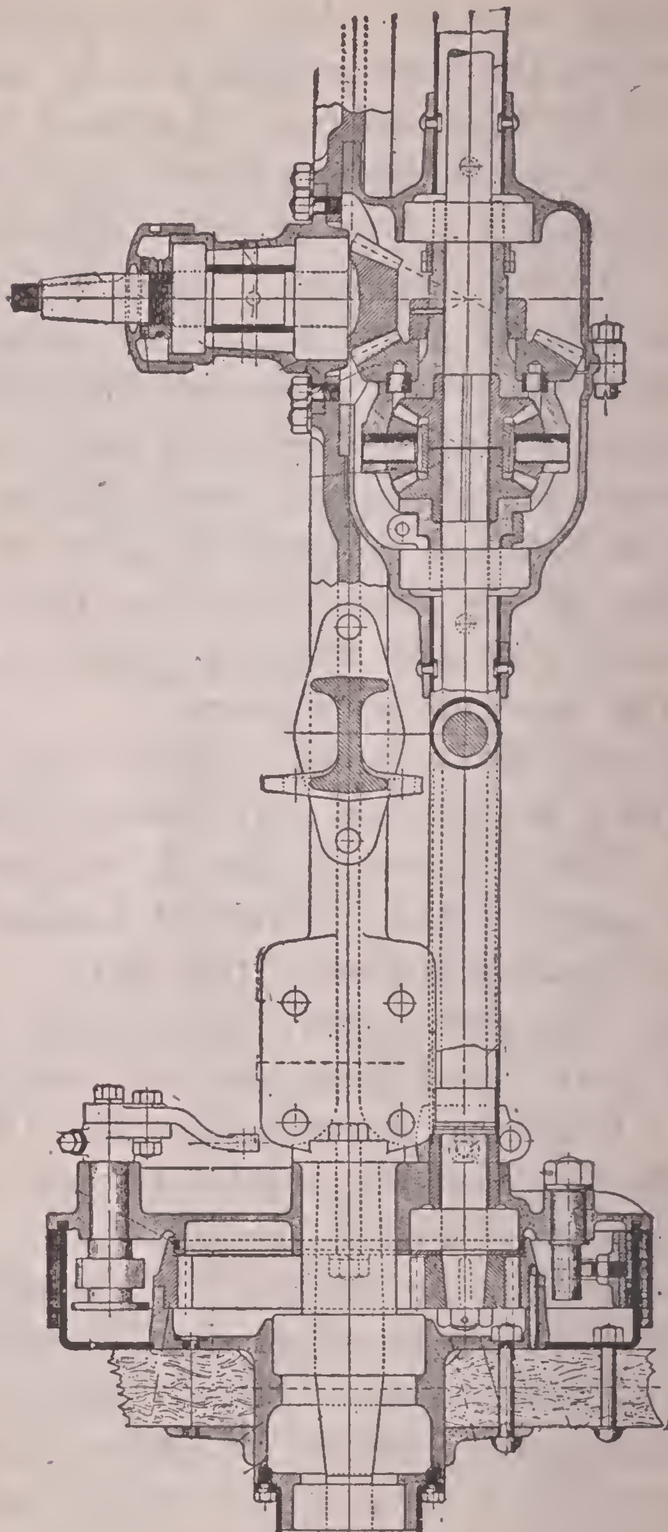


Fig. 20
Internal Gear Rear Axle

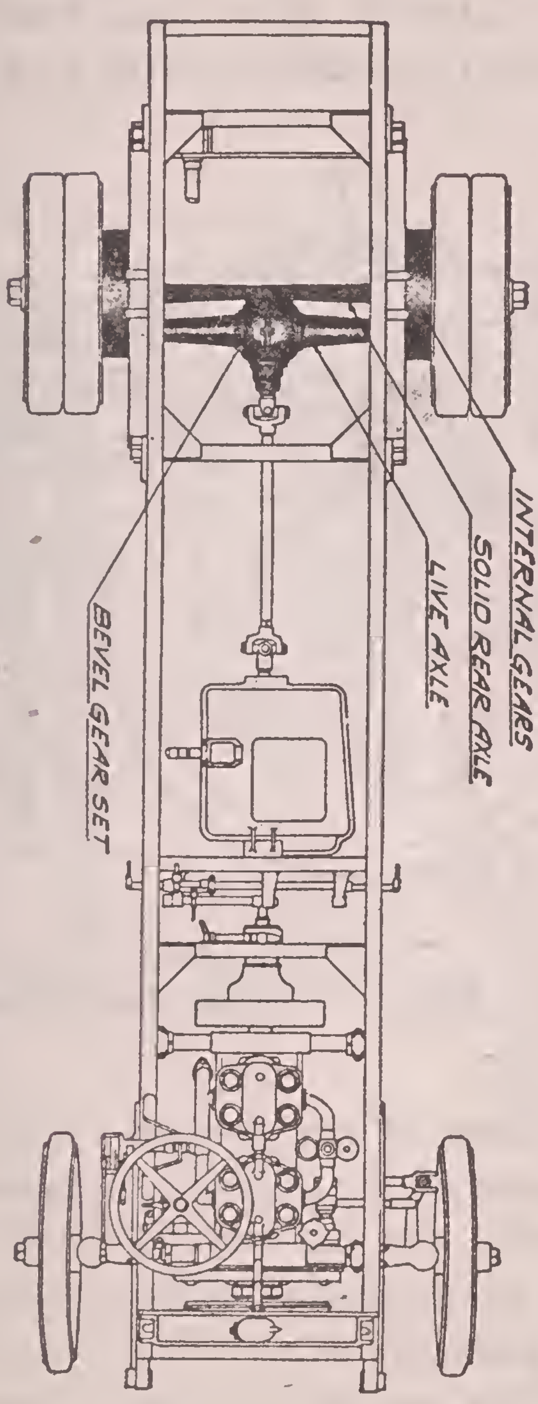


Fig. 21
Truck With Internal Gear Axle

Figure 21 shows the application of another form of internal gear axle having a front mounted drive member (Clark) on a motor truck chassis.

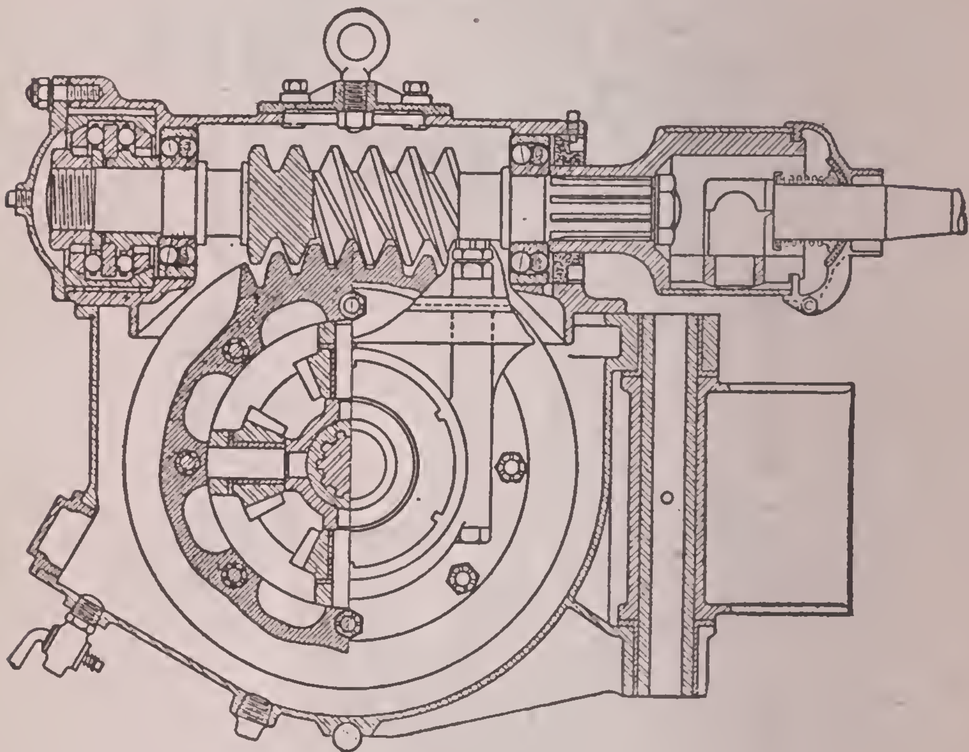


Fig. 22
Worm Drive for Rear Axle

Axle, Rear, Worm Driven. The worm type of rear axle is one of the best known and most widely used for commercial cars and electric vehicles, while it also finds a limited application on gasoline cars. The worm driven axle is especially suited to heavy loads and low vehicle speeds because of its ability to provide a great reduction of speed between the driving and driven shafts together with mechanical simplicity.

The principle of the generally adopted construction is shown in Figure 22 which illustrates a worm mounted above the worm wheel. The differential and the remaining parts of the axle are similar to the corresponding parts as found in the ordinary form of bevel gear constructions. The mounting of the worm must provide

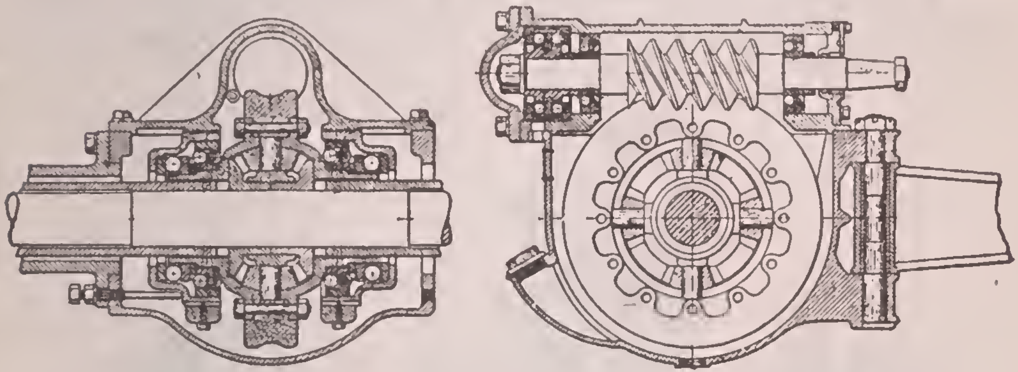


Fig. 23
Ball Bearing Mounting of Worm Gear

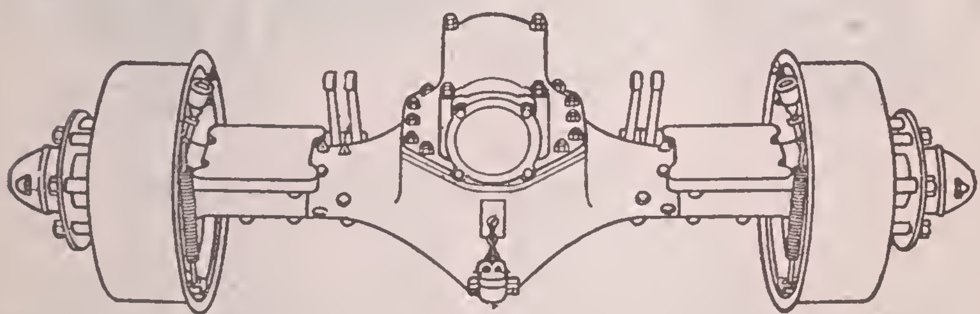


Fig. 24
Exterior of Worm Drive Axle

for withstanding a heavy end thrust inasmuch as it is the push of the worm against the gear which must drive the car. In top-mounted worms, the type generally used, the thrust of driving the car forward is taken at the rear of the worm, while in a bottom-mounted worm it is taken at the front. With ball bearing mounted worms, the thrust from either direction, traveling forward or backward, is taken principally by the rear bearing by fixing the worm shaft so that it is held against lengthwise movement by this bearing only, the front bearing being left free to float and carry only the radial load.

Figure 23 shows both a side and rear end view of the application of worm drive in a

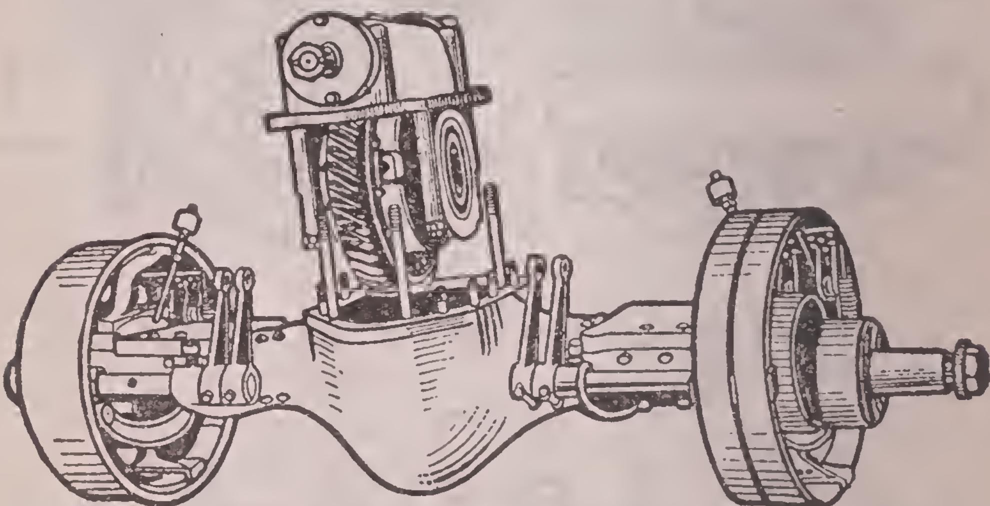


Fig. 25
Removal of Worm and Worm Carrier

truck axle. It will be seen that thrust bearings of ample size are placed at each side of the differential and worm gear in spite of the fact that the side thrust is less than with bevel gear axles.

Figure 24 shows the external appearance of a complete worm drive axle (Sheldon) while Figure 25 shows the worm, worm wheel, differential and their carrier lifted part way out of the top opening in the main axle housing.

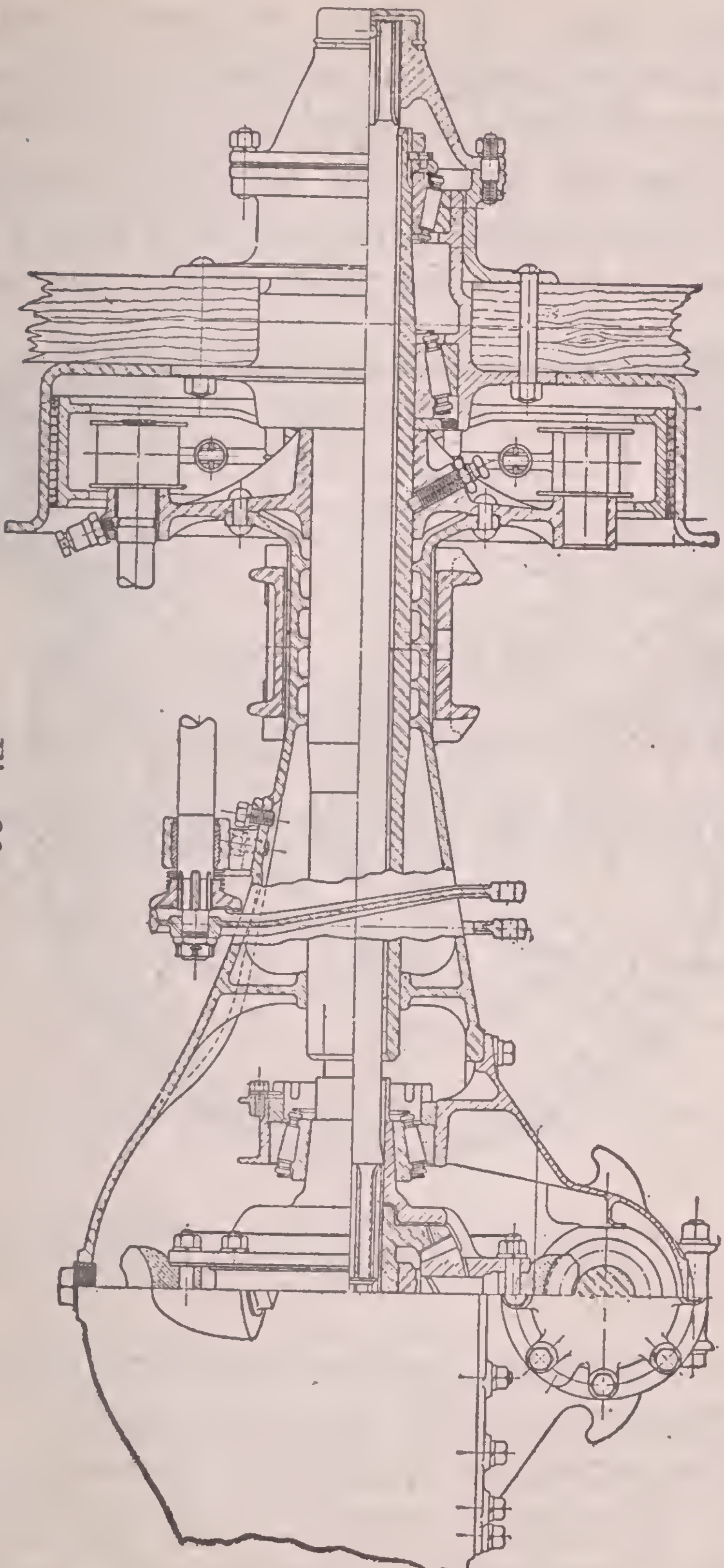


Fig. 26
Roller Bearing Worm Drive

The type of worm commonly employed requires practically no adjustment for meshing because the wear is distributed over such large surfaces that the initial setting is maintained. The large contact area and low unit pressure allow the use of dissimilar metals against each

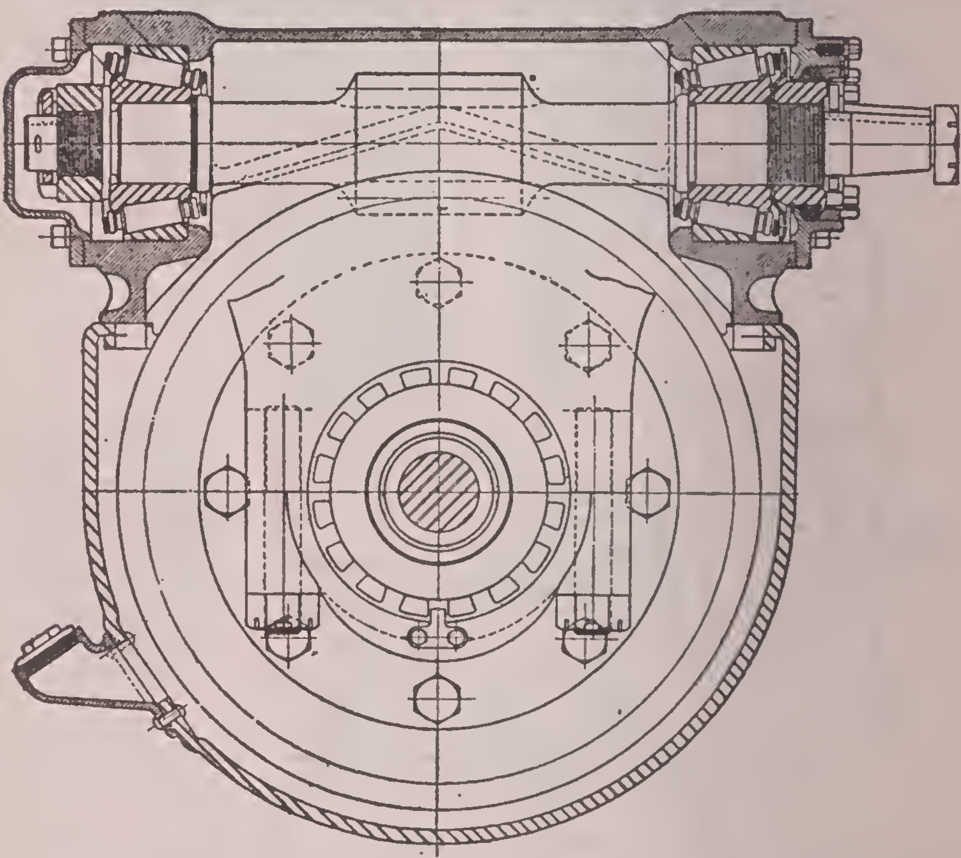


Fig. 27
Roller Bearing Mounting of Worm

other, steel being used for the worm and bronze for the worm gear in almost all cases.

The worm gear is quiet in service and permits of complete enclosure against dirt and dust. These features, together with fewness of parts due to the single reduction are among its advantages. The greatest fault with the worm gear axle is its weight in proportion to the load carried, this weight being required because of the loads imposed on the slowly moving parts. Great power can be exerted through a worm, a fact that is familiar to most people because of the use of various forms of screw and worm gearing to handle heavy loads.

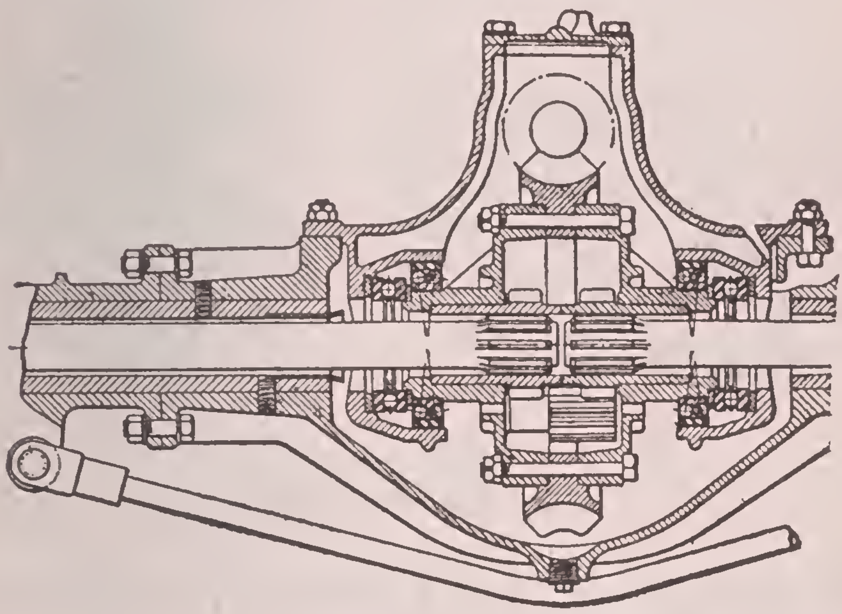


Fig. 28
Worm Drive Axle With Spur Gear Differential

Figure 26 shows a rear end section of a worm driven rear axle whose parts are carried by roller bearings of the tapered type. Figure 27 shows a side elevation of the same axle (Timken) and illustrates the method of taking the forward driving thrust on the rear bearing of the worm shaft and the reverse thrust on the forward bearing, this method being necessary because of the fact that taper roller bearings take thrust in but one direction. In the axle shown the comparatively light thrust from the sides of the worm gear is taken by opposed roller bearings.

All of the axles shown and most of those in use employ what is called a straight worm, that is, a worm having a straight face and a thread parallel on its outside edges to the worm axis.

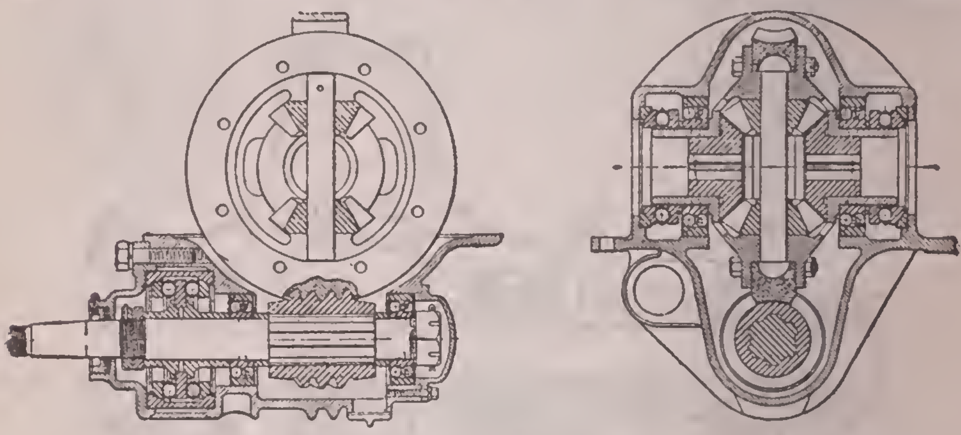


Fig. 29
Bottom Mounted Worm

This type avoids the necessity for great accuracy in end adjustment.

In Figure 28 is shown a rear elevation of a worm drive axle (Pierce) using ball bearings and spur gear differential.

Figure 29 illustrates the method of carrying the worm below the worm wheel, a practice which is not commonly found except in a few electric cars. Here it will be seen that the large thrust bearing is placed ahead of the worm itself. It is claimed for the underneath worm that it is better lubricated because the bath of oil always surrounds the surface in contact.

Batteries—Dry. A dry battery of the usual type consists of a zinc cell which forms the negative element of the battery.

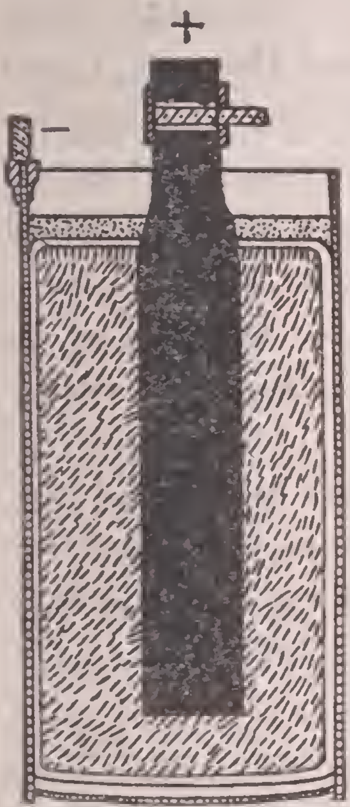


Fig. 31
Section Through
Dry Cell

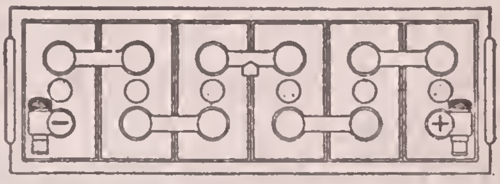


Fig. 30
Six Cells Boxed to Make
a Battery

Dry Batteries are very generally used on moderate speed and low-priced cars. They are simple in construction, comparatively simple in operation, and their action is easy to understand. Each cell is composed of three elements: The carbon, the zinc, and the electrolyte. The carbon usually takes the form of a round stick placed in the center of a cylindrical vessel made of zinc in sheet form. The space between the carbon and the zinc is filled with the electrolyte, generally a solution of sal-ammoniac, which is poured in on crushed coke. The top is closed, or rather sealed, with pitch to prevent the loss or evaporation of the liquid. Through this, project the ends of the carbon and the zinc, these being formed into binding posts for holding the wires. As this holding of the wires must be an intimate relation, the usual form is a threaded shank upon which a pair of nuts are mounted. Between these the wire to be connected is crushed or compressed by the moving together of the nuts.

The two poles or binding posts are called the positive and the negative, and are indicated by the + sign for the former and the — sign for the latter. Carbon being the positive element, the + sign attaches to it. Now, the act of connecting these terminals together so as to allow a flow of current allows of two different methods of procedure, a right and a wrong way, it is true, but that was not what was meant.

In one respect dry batteries have a decided advantage over storage batteries for ignition purposes, from the fact that on account of their high internal resistance they cannot be so quickly deteriorated by short circuiting.

On account of this high internal resistance, dry batteries will not give so large a volume of current as storage batteries, but a set of dry batteries may be short circuited for five minutes without apparent injury and will recuperate in from twenty to thirty minutes, while a storage battery would in all probability be ruined under the same conditions.

It is often desired to secure a greater voltage than one cell will give, or else to secure a source of current that will give a greater time of service than can be secured from the single cell. In either case, it is customary to combine two or more cells in certain definite combinations and connect them with each other in such a way that the desired voltage or length of life is realized. It is possible to make such combinations by using either dry or storage cells, although storage cells are usually boxed after forming.

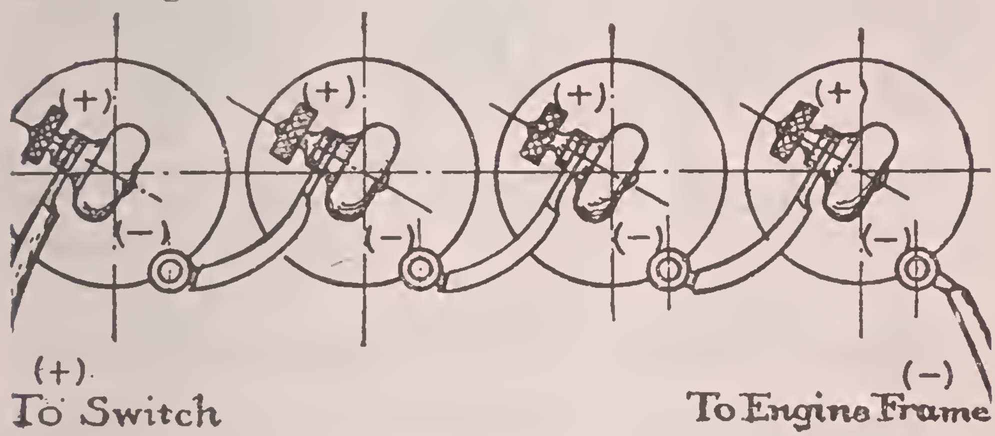


Fig. 32

The Ordinary Battery Connection, in Series

Two methods are usually employed, viz.: series, and multiple, or parallel. To connect dry batteries in series, the terminals are joined alternately, that is, the zinc of the first is connected to the carbon of the second, the zinc of the second to the carbon of the third, etc.

When so joined, the positive element is left free at one end, and forms the positive terminal of the group, which is then considered as a unit. The other free end (the negative) forms the negative terminal of the unit, see Fig. 32, which shows four cells connected in series.

Figure 33 shows four cells connected in parallel which means that all of the positive terminals are connected to one common wire, and all negatives are connected to another wire.

This mode of wiring up the cells gives a smaller output for the group. Thus if the individual batteries have an internal resistance

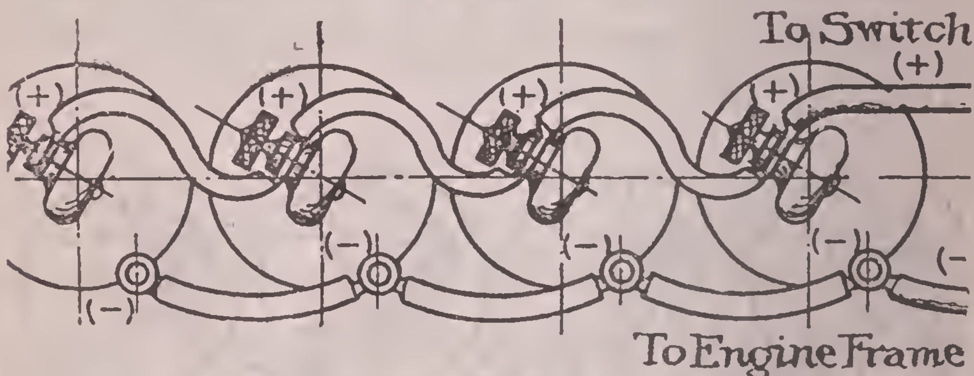


Fig. 33
Parallel Connections are Not as Frequently Used

which is low in comparison with the external resistance, the total output will be but slightly more than that of a single cell. If, on the other hand, the internal resistance is high relative to the external, the current will be roughly proportional to the number of cells.

Where the cells are divided into sets or groups of a small number (four is usual), and more than one of these sets are used at a time, there are again two methods of joining them. These two are the same as before, viz., series and multiple.

The former is very seldom used, if ever, but the other is rather common. When two or more sets of batteries, themselves connected in series are, as sets, joined in multiple the whole is spoken of as connected in series-multiple.

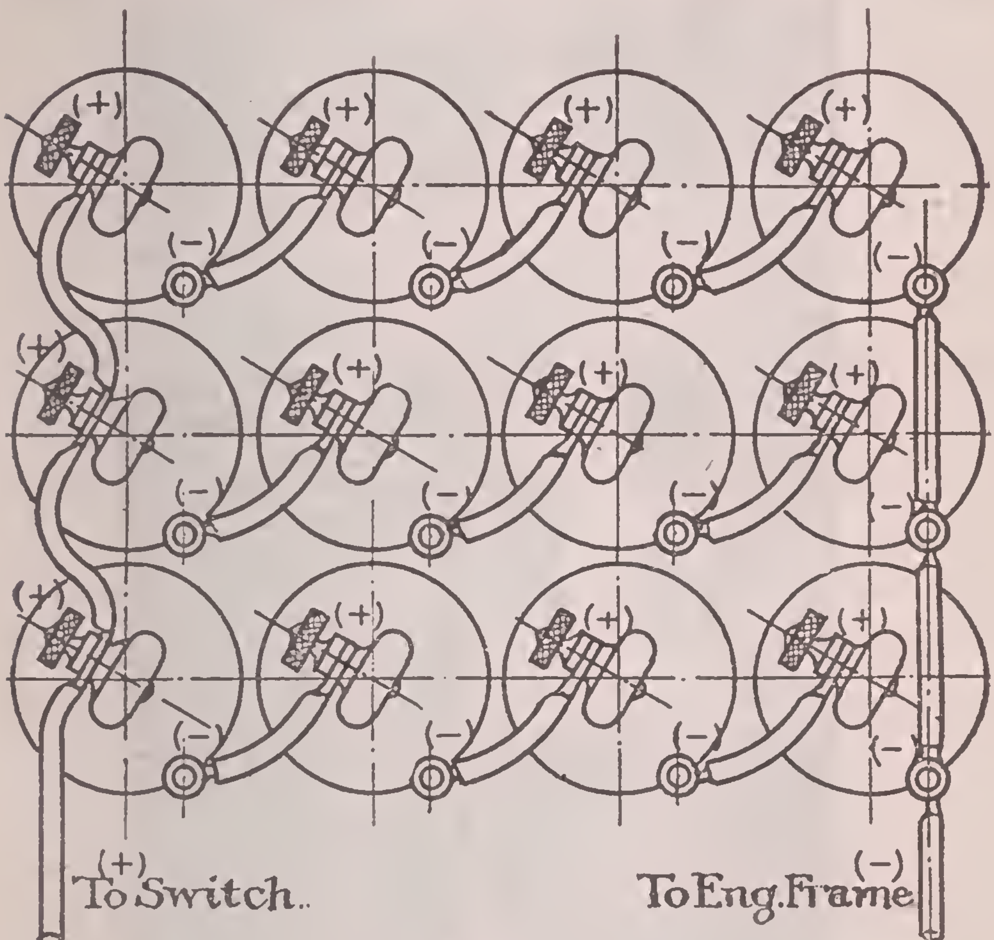


Fig. 34

Batteries—Storage. A storage battery as used in ignition service, is usually of the lead-acid type, in which the electrolyte is sulphuric acid and water of a density about 1.2— specific gravity. The plates are of two classes—positives and negatives—there being one more negative than positive in each nesting in a cell. The elements of a cell of storage battery are given in Fig. 35, and consist of the following: Positive plates A, of which there is one fewer than of negatives; negative plates B, of which there is always one more than positives; sepa-

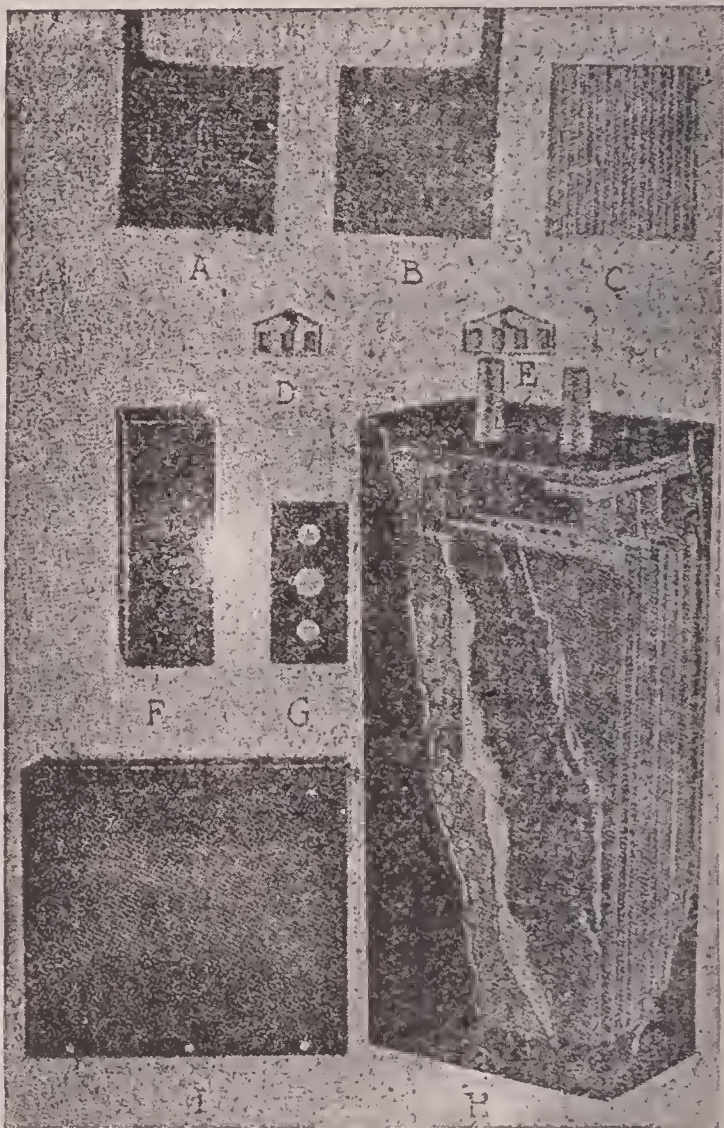


Fig. 35
Elements of Assembled Battery

rators C, which may be of wood, rubber, or other suitable material, and if of wood must be treated; positive strap D, the function of which is to connect all the positive plates, across the top, into electrical relation; negative strap E, the function of which is to connect all the negative plates, at the top, in electrical relation; battery jar F, made of rubber composition, light, strong and acid proof; cover for the jar G, with holes for the terminals of the elements, and a vent; assembled cell of battery H, showing the elements in place, separated, with cover on; ready for connections; and a battery box I, of oak, usually contrived to hold three cells of battery, sometimes two.

The positive and negative plates, called elements, consist essentially of a grid in each case, made of lead-alloy, in which antimony is used to engender stiffness. The grids are in divers forms, depending upon the views of several makers, the idea being to afford space for the active material, and to lock the same in, so that it will not drift out, as it is prone to do, under the action of the charging, and discharging current. Surface is the great requisite, and it is the aim to afford the maximum area of the finished plates, per pound of active material used; limiting the weight of the supporting grid, in so far as it is possible to do so.

The voltage of a battery of this type is usually 2.2 volts when the circuit is closed, but it drops to 2 volts within the first hour of using, which pressure it usually maintains during the next 5 hours, after which the voltage declines at a rapid rate.

Adding Water to Cells. In service water

will have to be added to the cells to compensate for evaporation, and for the loss that takes place during charge. brought about by the entraining of water with the bubbles of gas that shoot off and out of the jars, if they are open, that is to say, if the covers are removed before and left off during charging, which is not usually the case. The result in any event is in favor of increasing strength of the electrolyte, and water will have to be added from time to time in order that the plates may not be exposed to the atmosphere above the line of active material; which is a point that must be cared for if the battery is to last for a long time. The water so added should be pure—distilled—and the right quantity to add, will be determined by means of a hydrometer placed in each cell between the separators if there is sufficient room, or the electrolyte may be withdrawn through the utility of a gun made of hard rubber with a long slender neck. The test should be made when the battery is charged and every cell should be examined rather than to test one cell and conclude that all are in an average condition.

Storage Batteries—Care of. Among the troubles that ultimately attend batteries in service the following are the most conspicuous:

Hardening of negative elements; local action; buckling of plates; shedding of active material; sulphation; reversal of negative elements; disintegration of grids; protruding active material; deformation of separators; broken jars: incipient short circuits; defective electrical contact: loss of capacity; loss of voltage; corrosion of plates, and needle formations.

Hardening of the negative elements will follow if they are exposed to air, as when the electrolyte is allowed to fall below the level of the plates, from any process that will produce over-oxidization if the temperature is allowed to increase much above 90 degrees Fahrenheit. When the negative elements are hard, to reduce them back to the normal condition, assuming the process is not too far gone: Remove the elements from the jar, place the negatives in a cell, with dummy positives, and charge until the negatives are corrected, taking care not to charge at a too high rate. High temperature and excess boiling should be avoided. If the negatives are charged in their own cell with the regular positives the positives will be damaged by the excess charging that will be necessary to reduce the negatives. When the negatives are sufficiently charged to correct the evil they may be returned to their own cell, and when connected up with the positives the cell will be ready to go into service again, if in the meantime the positives are given such attention as their condition would seem to indicate. Local action, following impurities in the electrolyte, will only be prevented as much as it is possible to do so when the electrolyte is removed and pure electrolyte substituted in its stead. This should be done when the cells are fully charged

The electrolyte will hold most of the impurities when the battery is in the fully charged state.

Buckling of plates, when batteries are defective in design, rather than in cells of normal characteristics, is a trouble that will follow in any cell if the discharge is allowed to extend below 1.8 volt as indicated by the cadmium test, rather than by the usual potential difference reading across the two sets of elements in the cell. If the rate of discharge is excessive, a condition that is not likely in ignition work, buckling will follow also. Short-circuiting the elements to see if the battery is alive will tend to buckle the plates, due to the heavy discharge, and the uneven rate of discharge over the surfaces of the elements. In defective construction, if the active material is not of the same porosity, thickness, and in the same condition all over the surfaces of the plates, buckling will follow.

Shedding of the active material, to a slight extent, is a normal condition of batteries; and to prevent trouble due to incipient short circuits, such shedding is cared for by having a space in the bottom of cells to hold such shedded material. When elements are of inferior design and improperly constructed the active material will shed at a rapid rate, and the user of the battery can do nothing more than demand a new battery to replace the defective one. If charging is done at a too rapid rate the active material will be loosened by the rapidly escaping gas, and even on discharge, if the rate is high, the shedding of active material is likely to follow.

Sulphation, which is a normal expectation during discharge of a battery, introduces serious complications under certain conditions as when the active material is not in intimate contact with the grids thus allowing the electrolyte to get between the grids and the active material, with the result that sulphate, which is a high resistance material, isolates the grids and reduces the efficiency of the cell in two ways; first, by increasing the ohmic losses, and, second, by lowering the chemical activity. Excess sulphate is prone to form when the electrolyte is out of balance, and one of the best ways to abort this action is to keep the electrolyte within the prescribed limits of strength. If sulphate is allowed to form until white crystals show over the surfaces of the plates, it is highly improbable that the cells will ever be of sufficient service to warrant continuing them in service. The only way to afford relief lies in reducing the growth of sulphate by continuous charging the sick elements in a cell with dummies until the sulphate is reduced. A slow rate for a long time may bring about a reform.

Negative elements to be reversed must be below capacity, or the cells must be discharged to zero and then reversed. In charging it is always necessary to make sure that the connections are made in such a way that current will flow into the battery, rather than out of it. Voltmeters in which permanent magnets are used will serve as polarity indicators, and with them it is possible to proceed with safety. If a battery is connected up in reverse when it is put on charge, instead of being charged it will be discharged, and then charge in reverse. While it is discharging it will deliver current to the line.

Disintegration of grids will follow if the impurities are allowed to enter the electrolyte, as iron, etc. Continued charging will also have the effect of reducing the grids to form salts of lead.

Protruding active material indicates a lack of binding relation between the girds and the active materials. It may often be replaced by compressing the plates in a plate press. Deformation of separators, when they are made of rubber compound, follows when the cells are allowed to heat beyond a certain point. This trouble will be aborted if the cells are charged at a normal rate, and if the temperature is not allowed to increase beyond about 90 degrees Fahrenheit. When wood separators are used they will slowly rot and in time it will be necessary to replace them.

Broken jars will allow the electrolyte to leak out, and frequently the fracture is but a minute crack, so that it is well to be on the lookout for just this kind of trouble. If the jars are properly nested and motion between them is prevented they will as a rule serve without breaking.

Incipient short circuits are likely to go unnoticed. They are generally due to detached particles of active material that lodge between the plates, especially in vehicle and ignition types, owing to the short distance separating the plates, and the use of separators, such as perforated rubber in the absence of wood, which have the virtue of being porous but too close to allow the active material to bridge across the space between the plates.

Defective electrical contact is due to corroding of joints that are not made by burning.

Loss of capacity may be traced to such causes as: If the electrolyte is out of balance or below the level of the top of the plate; loss of active material from the grids; sulphate formed on the surfaces of the grids, isolating the active material; lack of porosity of the active material; impurities and sulphate clogging up the pores of the active material; low temperature; high temperature; persistent sulphation, and intercell leakage due to electrolyte spilled over the surfaces, especially if jars are in actual contact with each other.

Loss of voltage, as distinguished from loss of capacity, follows in a battery when one or more of the cells are dead or below voltage. If one or more of the cells are reversed they will set up a counter-electro-motive force, and the over-all reading of the battery will be reduced accordingly. The remedy is obvious. All the cells should read the same way, and all should have the same difference of potential, respectively.

In view of the sulphated condition that attends all batteries that are discharged at a low rate for a long time, as is the case in ignition work, it is necessary to charge at a low rate for a long time in order to reduce the sulphate, which is in persistent form and very difficult to reduce. It will not be enough to correct the strength of the electrolyte once during the charging process for the reason that it will be difficult, if not impossible, to ascertain the condition of the same with any degree of accuracy, and the necessity for noting strength two or three times in the act of charging is apparent. When the battery is fully charged, which may take even sixty hours of continuous charging at a low rate, the electrolyte in every cell should stand at full strength, considering a state of full charge, and the color as well as other indications of a full charge should be fully noted. Boiling at a slow rate should be tolerated for several hours, but the temperature should be held at about 90 degrees Fahrenheit during the entire time. If a battery is charged at frequent intervals it will last longer in service, give less trouble in charging and will be more reliable in service. It is well to begin charging directly a battery is taken out of service as any delay after that time will result in a marked deterioration of the cells.

When a car is put out of commission, even for a few weeks, the battery should be given a light discharge, and a subsequent charge as often as once a week, until it is again brought back into use.

STORAGE BATTERIES — CHARGING. Positive plates in the charged state are of a velvety brown or chocolate color; negative plates have the color of sponge lead, which is very nearly light gray. When a battery is approaching a condition of full charge the color tones up quite noticeably, and it is possible to mistake a condition of full charge, if color alone is taken as the evidence; the exterior will have the appearance of full charge, since the active material, on the exterior surface, will reach its charged form first; if the thickness of active material on the grids is very thick, as it is likely to be in low discharge rate work. charging by color, as evidence of a state of full charge, will be to limited advantage. Details regarding the proper care and upkeep of storage batteries are given in the following pages.

STORAGE BATTERIES—TESTING. Tests for impurities in the electrolyte may be made as follows. For iron;

Neutralize a quantity of the electrolyte to be investigated, after diluting the same, by the addition of an equal amount of pure distilled water, using strong ammonia water for the purpose. To the solution, so neutralized, add one-thirtieth of the amount of the same of hydrogen peroxide, thus reducing any iron present to the ferric state. If a sample of this solution is rendered alkaline by the addition of a sufficient quantity of ammonia water, then, if iron is present, enough to amount to anything of great moment, from the battery point of view, a brownish red precipitate will form. A test for chlorine is as follows:

Make a solution of nitrate of silver in the proportion of 20 grams of the same, in 1,000 cubic centimeters of pure distilled water, and add a few drops of this solution to a small quantity of the electrolyte to be investigated; if chlorine is present the solution will turn white, owing to the formation of chloride of silver, which will precipitate out.

A test for nitrates is as follows: In a test tube, holding 25 cubic centimeters of electrolyte to be tested, add 10 grams of ferrous sulphate; to this carefully add 10 cubic centimeters of chemically-pure sulphuric acid by pouring the same slowly down the side of the tube; in the presence of nitric acid, a brown solution will form between the electrolyte to be tested, and the concentrated solution of sulphuric acid.

The presence of copper may be detected from the fact that when ammonia solution is added to electrolyte, a bluish-white precipitate will form. In testing for mercury, lime water, if it is added to electrolyte in which mercury is present will evolve a black precipitate. Testing for acetic acid is as follows: To a small quantity of the electrolyte to be tested, add enough ammonia water to render the same neutral; ferric chloride added to this solution will cause the same to turn red in the presence of acetic acid and the solution will then bleach, provided hydrochloric acid is added, thus affording conclusive proof of the presence of the undesired acetic acid.

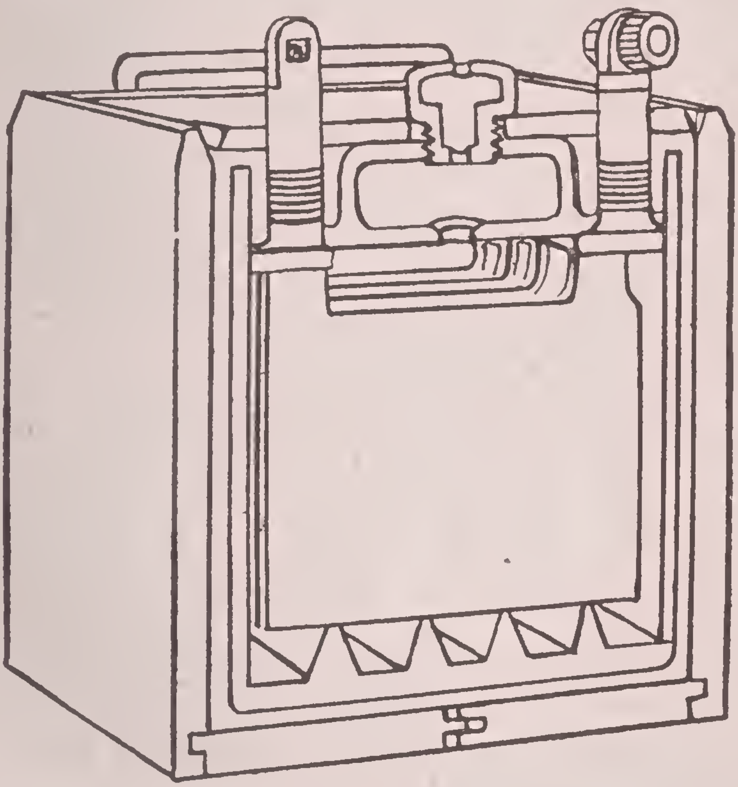


Fig. 36
Section Through Storage Battery Used For Lighting and Engine Starting

Battery, Storage, Starting and Lighting Types. The foregoing description and instructions relating to storage batteries apply equally well to ignition, starting and lighting types. The following rules include the standard battery instructions adopted by the Society of Automobile Engineers for the installation and care of batteries used in connection with electric lighting and starting systems.

Batteries must be properly installed. Keep battery securely fastened in place. Battery must be accessible to facilitate regular adding of water to, and occasional testing of, solution. Battery compartment must be ventilated and drained, must keep out water, oil and dirt and must not afford opportunity for anything to be laid on top of battery. Battery should have free air space on all sides, should rest on cleats rather than on a solid bottom, and holding devices should grip case or case handles. A cover, cleat or bar pressing down on the cells or terminals must not be used.

Keep battery and interior of battery compartment wiped clean and dry. Do not permit an open flame near the battery. Keep all small articles, especially of metal, out of and away from the battery. Keep terminals and connections coated with vaseline or grease. If solution has slopped or spilled, wipe off with waste wet with ammonia.

Pure water must be added to all cells regularly and at sufficiently frequent intervals to keep the solution at proper height. Add water until solution is level with inside cover. Never let solution get below top of plates. Plugs must be removed to add water, then replaced and screwed on after filling. The battery should preferably be inspected and filled with water once every week in warm weather and once every two weeks in cold weather. Do not use acid or electrolyte, only pure water. Do not use any water known to contain even small quantities of salts of any kind. Distilled water, melted artificial ice or fresh rain water are recommended. Use only a clean metallic vessel for handling or storing water. Add water regularly, although the battery may seem to work all right without it.

The best way to ascertain the condition of the battery is to test the specific gravity (density) of the solution in each cell with a hydrometer. This should be done regularly. A convenient time is when adding water, but the reading should be taken before, rather than after, adding water. A reliable specific gravity test cannot be made after adding water and before it has been mixed by charging the battery or running the car.

To take a reading insert the end of the rubber tube in the cell. Squeeze and then slowly release the rubber bulb, drawing up electrolyte from the cell until the hydrometer floats. The reading on the graduated stem of the hydrometer at the point where it emerges from the solution is the specific gravity of the electrolyte. After testing, the electrolyte must always be returned to the cell from which it was drawn. The gravity reading is expressed in "points," thus the difference between 1.250 and 1.275 is 25 points.

When all cells are in good order, the gravity will test about the same (within 25 points) in all. Gravity above 1.200 indicates battery more than half charged. Gravity below 1.200, but above 1.150, indicates battery less than half charged. When the battery is found to be half discharged, use the lamps sparingly until the gravity is restored to at least 1.250. If by using the lamps sparingly, the battery does not come back to condition, there is trouble in the wiring or generator system which should be investigated and remedied immediately. Gravity below 1.150 indicates battery completely discharged or "run down." A run down battery is always the result of lack of charge or waste of current. If, after having been fully charged, the battery soon runs down again, there is trouble somewhere in the system which should be located and corrected. Putting acid or electrolyte into the cells to bring up specific gravity can do no good and may do great harm. Acid or electrolyte should never be put into the battery except by an experienced battery man.

Gravity in one cell markedly lower than in the other, especially if successive readings show the difference to be increasing, indicates that the cell is not in good order. If the cell regularly requires more water than the others, thus lowering the gravity, a leaky jar is indicated. Even a slow leak will rob a cell of all of its electrolyte in time and the leaky jar should immediately be replaced with a good one. If there is no leak and the gravity is, or becomes, 50 to 75 points below that in the other cells, a partial short circuit or other trouble within the cell is indicated. A partial short circuit, if neglected, may seriously injure the battery and should receive the prompt attention of a good battery repair man.

A battery charge is complete when, with charging current flowing at the finish rate given on the battery plate, all cells are gassing (bubbling) freely and evenly and the gravity of all cells has known no further rise during one hour. The gravity of the solution in cells fully charged as above is between 1.275 and 1.300.

If for any reason an extra charge is needed it may be accomplished by running the engine idle, or by using direct current from an outside source. In charging from an outside source use direct current only. Limit the current to the proper rate in amperes by connecting a suitable resistance in series with the battery. Incandescent lamps are convenient for this purpose. Connect the positive battery terminal (with red post, or marked P or +) to the positive charging wire and negative to negative. If reversed, serious injury may result. Test charging wires for positive and negative with a voltmeter or by dipping the ends in a glass of water containing a few drops of electrolyte, when bubbles will form on the negative wire. When charging, start at the starting rate and continue the charge at this rate until the cells gas freely. Then continue the charge for six hours at the finish rate. The specific gravity at the end of the charge should read between 1.275 and 1.300. If the specific gravity does not reach this point, continue the charge at the finish rate until the specific gravity stops rising, which is an indication that the battery is fully charged.

A battery which is to stand idle should first be fully charged. A battery not in active service may be kept in condition for use by giving it a freshening charge at least once a month, but should preferably also be given a thorough charge after an idle period before it is replaced in service. Disconnect the leads from a battery that is not in service, so that it may not lose charge through any slight leak in car wiring.

TABLE 4

LOAD CAPACITIES OF ANNULAR BALL BEARINGS
(New Departure at 600 rev. per minute)
Single Row Bearings.

Bearing No.	Balls Diam.	Balls No.	Cap. Lbs.	Bearing No.	Balls Diam.	Balls No.	Cap. Lbs.
200	7/32	7	135	208	7/16	14	1095
300	1/4	6	205	308	19/32	11	1590
201	7/32	7	175	408	13/16	9	2440
301	9/32	6	290	209	7/16	15	1175
202	7/32	8	215	309	21/32	12	2120
302	5/16	6	360	409	7/8	10	3140
203	1/4	8	280	210	15/32	15	1350
303	11/32	9	435	310	23/32	12	2540
403	1/2	8	820	410	15/16	10	3585
204	9/32	8	390	211	1/2	16	1640
304	11/32	10	485	311	25/32	12	3000
404	9/16	8	1035	411	1	10	4100
205	5/16	12	480	212	17/32	16	1850
305	13/32	11	745	312	27/32	12	3500
405	5/8	8	1280	412	1 1/16	10	4625
206	11/32	13	630	213	9/16	17	2215
306	15/32	11	990	313	29/32	12	4045
406	11/16	9	1745	413	1 1/8	10	5190
207	13/32	13	880	214	19/32	17	2455
307	17/32	11	1275	314	31/32	12	4620
407	3/4	9	2075	414	1 1/4	10	6415

Double Row Bearings.

300	1/4	8	255	311	11/16	11	3690
301	1/4	8	360	312	3/4	11	4200
302	1/4	10	440	313	13/16	11	4825
303	5/16	8	515	314	7/8	11	5550
304	5/16	9	575	315	15/16	11	6400
305	3/8	9	1000	316	1	12	7200
306	7/16	9	1385	317	1 1/16	12	8200
307	1/2	10	1815	318	1 1/8	12	9100
308	17/32	11	2245	319	1 3/16	12	10000
309	9/16	11	2850	320	1 1/4	12	12000
310	5/8	11	3275	321	1 5/16	12	13400

Bearings, Ball. Ball bearings may be broadly divided into three classes—thrust, cone and annular. Thrust bearings are those intended to sustain end thrust, and in them care must be exercised to see that the points of contact of the balls are exactly opposite, and that the grooves in which the balls run are formed to a sectional radius a little larger than that of the balls, thereby securing safe and easy movement of the balls. These grooves must be designed not only to give smooth rolling contact, but so that a measurable area of the ball's surface contacts with the race. It is also possible for a thrust bearing to act at the same time as a radial bearing, in which case, however, the four-point system must be used. In thrust bearings the balls are constantly under pressure and table 5 gives suitable loads for equal shaft diameters and revolutions for different sizes and numbers of balls:

TABLE 5.

Shaft Diameter, in inches.	Allowable Load lbs.	R.P.M.	Number of Balls	Ball Diameter in Inches
2.55	550	500	22	⅜
2.55	1,000	500	15	⅝
2.55	1,200	500	14	11/16
2.55	1,300	500	13	¾
2.55	1,600	500	12	⅞
2.55	1,800	500	10	1

The adjustable cone bearing, Fig. 39, has been used in millions of bicycles with excellent results, but under large loads has been found inadequate. A ball can roll freely only with opposite points in contact, and every third or fourth point of contact involves more or less spinning, or sliding movement of the ball, which shortens its life, and the bearing must operate to the detriment of the contact surfaces.

The third and great type of ball bearing is the so-called annular one intended for radial loads. It consists of three elements—two races and the balls. The new annular bearings require no adjustment or fitting, and the rolling action of the balls takes place without interference of friction. A wonderful advantage of this bearing is that as high as 96 per cent of the space between the races can be filled with balls, the balls being introduced through filling lots whose size is a little less than the diameter of the balls to be introduced, so that the balls are forced between the two races under pressure and by virtue of the elasticity of the material. In the annular bearing but 30 per cent of the balls are under load at one time, and it is possible for equal axle sizes and speeds to use different dimensions and loading according to the size of the balls. Table 6 gives suitable loads for equal shaft diameter, and revolutions for various sizes, and numbers of balls.

TABLE 6.

Shaft Diam. inches	Allowable load on Bearing, lbs.	R. P. M.	No. of Balls	Diam. of Balls, Inches
3.14	1,000	500	20	$\frac{1}{2}$
3.14	1,300	500	21	$\frac{9}{16}$
3.14	2,500	500	12	1
3.14	3,000	500	14	$1\frac{1}{16}$
3.14	4,500	500	11	$1\frac{7}{16}$

Annular ball bearings are also made with two rows of balls, and in the majority of them each ball is in a separate cage. Experiments have proven that, where the balls contact with one another, after a few years the friction results in grooves being worn in them. In Fig. 37 is shown the form of separator used in the F. & S. bearings. If in the application of this bearing it is

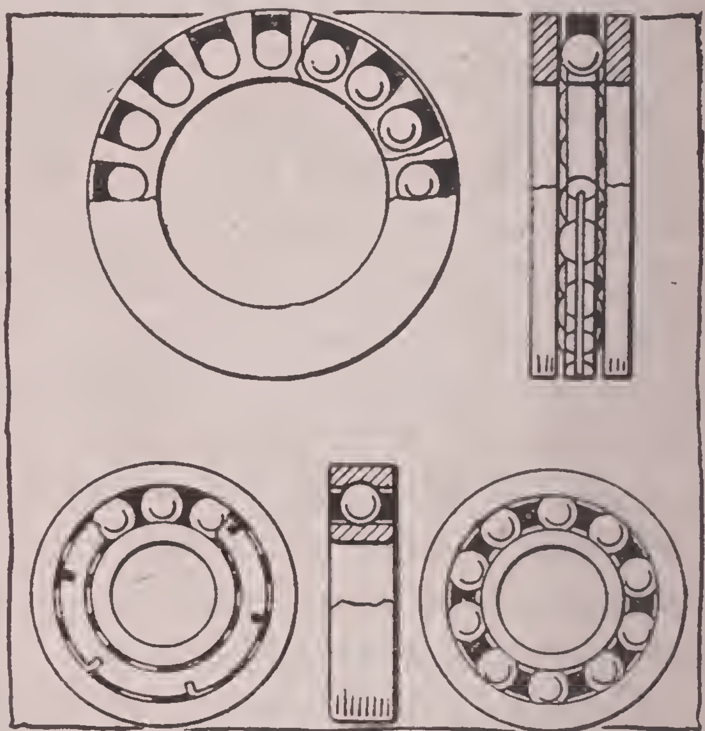


Fig. 37
F & S Bearing Separator

necessary to sustain heavy axle loads, it is absolutely necessary to add an independent thrust bearing, or to employ a combination bearing which takes the place of bolt thrust and radial loads.

Ball Bearings—Two in One. Figs. 38, 39, and 40 illustrate a ball bearing manufactured at Bristol, Conn., which owing to its dual ability as as expressed by its name ("two in one") is especially adapted to automobile service. Its makers claim that it is able to withstand radial or thrust loads, or any combination of the two, with the use of but a single bearing with its attendant simplicity of mounting. In order to bring about this result, two rows of balls are employed in staggered relation to one another, and the ball races are so arranged that the line

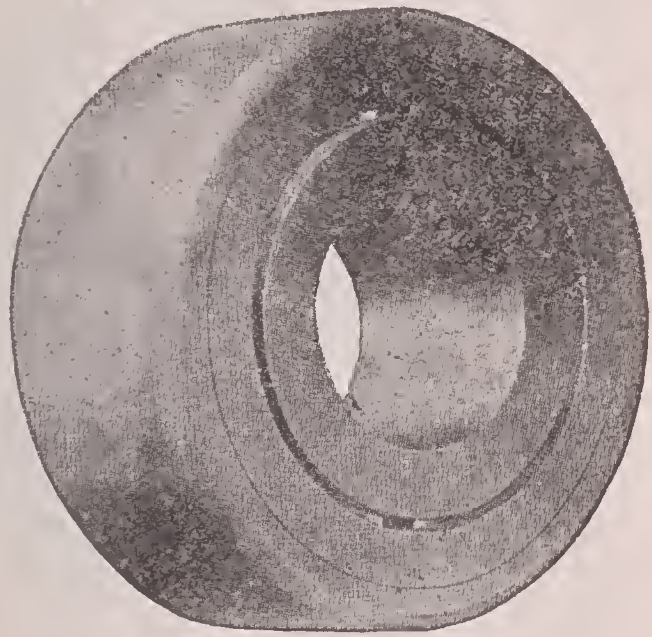


Fig. 38
Assembled Bearing Complete

of pressure is either at an angle of 45 degrees or 60 degrees with the horizontal, when the axis of rotation of the bearing is in a horizontal plane.

Figure 38 shows the permanent assembly of the bearing, sufficient metal being provided in the shell to permit of drawing the latter tightly over the cups.

Figure 39 shows the various parts of this bearing, and Fig. 40 is a semi-sectional view showing the order of their assembly, from the shaft outward, as follows; the cone, the separator, the two cups and the shell. It will be noticed that the line of pressure of the cone, cups,

Fig. 39

and balls is at an angle of 45 degrees with the horizontal, and this feature applies equally to both rows of balls, thus adapting the bearing to withstand a load from any angle. Two semicircular races are turned in the cone to receive the balls, while the sheet metal separator is so stamped that the ball retaining notches are staggered with reference to each other. These openings are made slightly larger than the ball diameter, so that the contact between the ball and separator is said to be a point contact at one end of the axis of rotation, while the weight by separator is carried on the balls at the top of the bearing. By maintaining the relative positions of the balls at all times, cross friction

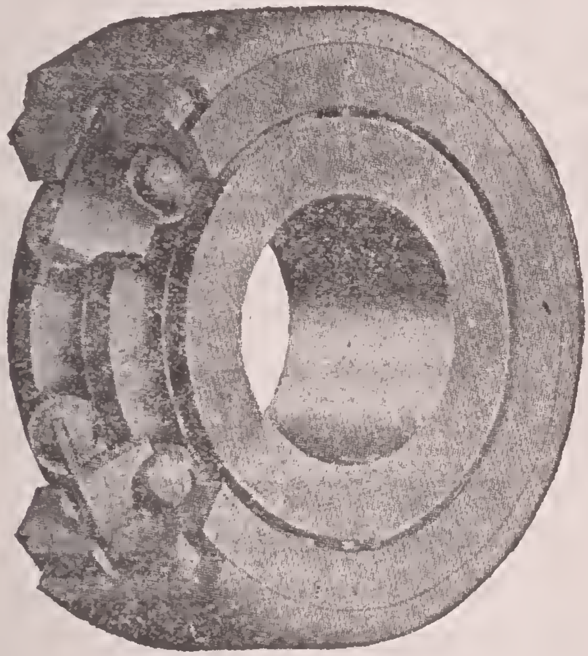


Fig. 40
Sectional View of Bearing

it is claimed is entirely eliminated, while the friction introduced by the use of the separator is practically negligible.

Ball Bearings—Lubrication of. Ball bearings must be so housed in as to retain lubricant and exclude dust, grit, etc. An impression that ball bearings will operate without lubricant is quite general. It is barely possible that absolutely true spheres might roll on absolutely true surfaces if both were made of materials that were absolutely inelastic, and therefore would remain true under load. But since such absolute perfection of the shape is not to be had, some means must be taken to provide and retain lubricant.

Rust and acid must be kept out of ball bearings. Experience and most carefully conducted tests have proven that long life under load can be realized from ball bearings only when the surfaces are not only true, but are also highly polished and smooth. Roughness will be broken down and leave still greater roughness. Rust and acid will destroy originally true and smooth surfaces. Since not a few lubricants contain free acids, care in their choice must be exercised. Plentiful lubrication and a properly closed mounting are safeguards against rust.

In the lubrication of ball bearings it is advisable to use vaseline; or, when a lubricant of greater body or stiffness is desired, to use a mixture of vaseline and some high-grade mineral grease. The grades known as semi-fluid are very well suited for this use and any combination may be used with success in such cases.

Annular Ball Bearings. In the annular ball bearing, Fig. 42, a race of balls C is contained between an inner retainer A and an outer race B, there being grooves in the opposing surfaces of these to receive the balls. In a Hess-Bright bearing of this type, as illustrated in Fig. 41, the entire space between the races C and B is not occupied by balls, but is utilized in different ways. In this only enough balls to make a half circle in the bearing are used, and these are spaced apart by means of small helical springs. These springs contain oil pads of felt, and are headed by sheet-metal discs that extend far

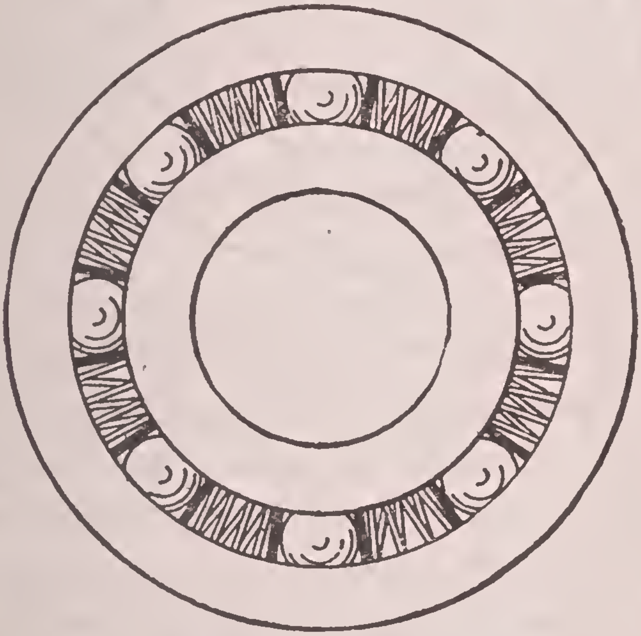


Fig. 41
Hess-Bright Bearing

enough into the grooves to prevent sidewise displacement of the springs, without, however, producing any more than a negligible friction. Assembling this bearing one race is placed eccentric to another race and the requisite number of balls slipped into positions, after which the races are made concentric and the balls regularly distributed. This dóne, the separating springs with lubricating means are installed.

Once the springs are in place the tension of them is such as to make the bearing self-contained.

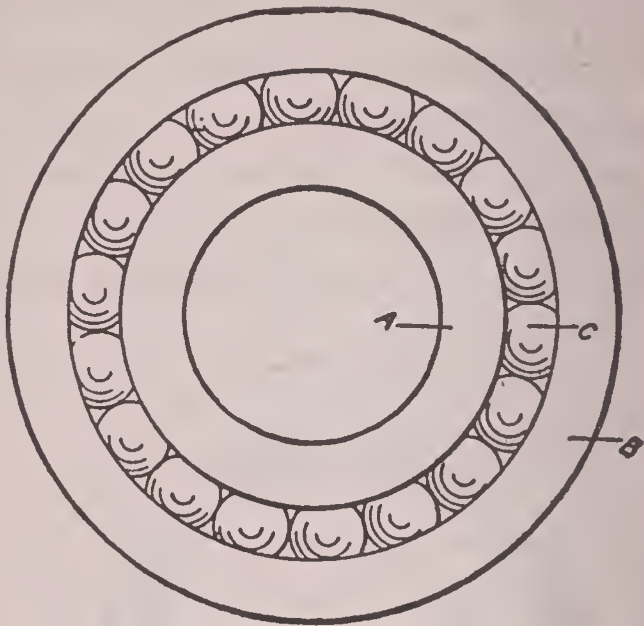


Fig. 42
Annular Ball Bearing

It is not practicable to disassemble or repair the various forms of annular ball bearings in the ordinary shop. These forms are not adjustable and are not designed to be taken apart. It is quite possible to reform the races and to insert new balls when the bearing is badly worn or scratched, but such work must be done with machinery and tools especially designed for handling it. Ball bearing repairs are handled by various companies who specialize on such work and it will always be advisable to communicate with one of them.

Bearings, Plain. The composition of metals for plain bearings is given under the heading "Alloys." Plain bearings are used generally for connecting rod crank pins, wrist pins and crank shaft bearings in automobiles. The material and dimensions are determined according to the pressure exerted on the bearing which is measured in pounds per square inch for the projected area of the bearing, this area being equal to the bearing diameter multiplied by its length. The maximum allowable pressure is one beyond which the oil film will not be maintained, this in turn depending on the characteristics of the oil used and the method of introducing the lubricant between the bearing surfaces.

Some of the generally accepted limits for maximum bearing pressures in automobile construction are as follows: For the crank shaft; front bearing 850 pounds, rear bearing 700 pounds, center bearing 900 pounds. For connecting rod lower end bearings 1400 pounds and for wrist pin bearings 2200 pounds.

Plain bearings are held by steel journals and caps and the bearing proper, called the liner, may either be in one piece composed entirely of the bearing metal or made by applying a shell of the bearing metal inside of an outer shell of some stronger material such as steel or hard bronze. The halves of split bearings are held in proper relation by thin strips of metal called shims.

Hard and Soft Bearings. There are two general classes of solid bearings, those which contain a large per cent of copper and a small amount of the softer metals; which are known as hard metals, as brass or bronze. Those which contain a large proportion of tin or lead and a small per cent of copper are known as soft metals—as babbitt-metal, anti-friction metal and white metal.

In some instances and under certain conditions it has been found that a good close-grained cast iron makes an excellent bearing metal. Being of a granular nature, it has the property of retaining the lubricant in place, even when highly polished and under great pressure, with

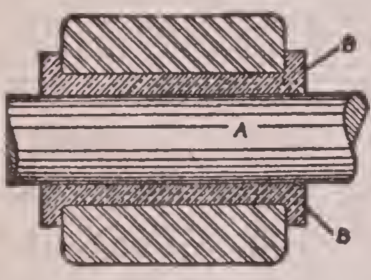


Fig. 43

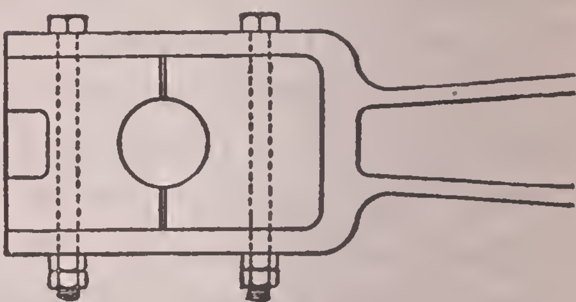


Fig. 44

Types of Plain Bearings

a low co-efficient of friction, but is too brittle to withstand severe shocks.

Plain Bearings. Plain solid bearings are used on many parts of an automobile, particularly in the engine and transmission bearings, although ball and roller bearings are taking their place in many constructions. The majority of the cars use brass, bronze or babbitt-metal on the main and crankshaft bearings, while ball and roller bearings are used on the transmission and wheel bearings. A typical plain bearing is shown in Fig. 43, in which A is the journal made of steel, while the bearing members shown at

B. B. are made of either brass, bronze, or babbitt metal. Figures 44 and 45 show different types of connecting rod bearings. For plain-bearings, the shafts of which are continuously running at a high rate of speed, such as motors and speed-change gears, the working pressure

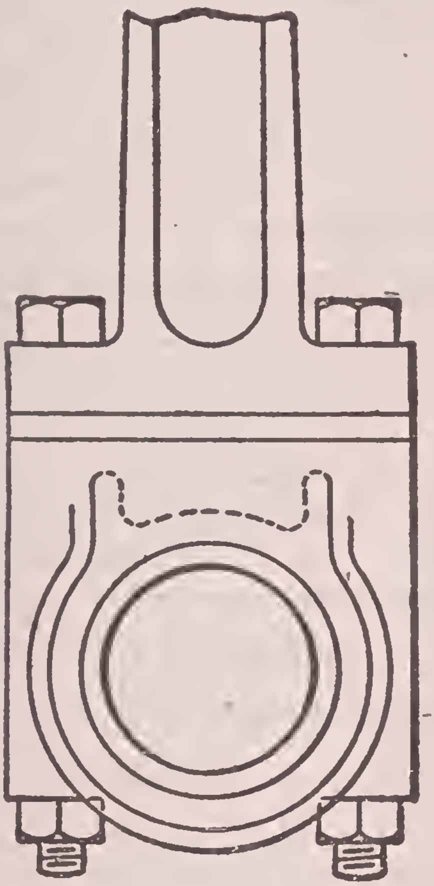


Fig. 45
Solid Connecting Rod Bearing

per square inch should not exceed 400 pounds. As the arc of contact or actual bearing surface of a journal bearing is assumed as one-third of the circumference of the journal itself, the pressure per square inch upon a bearing is therefore equal to the total load upon the bearing, divided by the product of the diameter of the journal times the length of the bearing.

Let D be the diameter of the journal or shaft at its bearing, and L the length of the bearing, if W be the total load or pressure upon the bearing and P the pressure in pounds per square inch of bearing surface, then

$$P = \frac{W}{D \times L}$$

If the total load or pressure on the bearing be known and the diameter of the shaft given, then the proper length of the bearing will be

$$L = \frac{W}{D \times P}$$

If the length of the bearing be known and other conditions as before given, then the proper diameter of the journal will be

$$D = \frac{W}{P \times L}$$

ADJUSTMENT OF PLAIN BEARINGS. The halves of split plain bearings will require adjustment or re-fitting after a considerable period of use and wear. This adjustment may be made either by removing a part of the shims, by filing the side of the retaining cap or by scraping the inner surfaces of the liners.

Shims are the thin metal pieces found between the halves of the bearing at each side. One shim should be taken out of each side of the bearing, the cap replaced and the holding bolts tightened. If the shaft still turns freely another pair of shims, one from each side, should be removed. This process should be continued until the shaft binds in the bearing. After this binding is secured, the cap should again be removed and one pair of thin shims replaced so that, when oiled, the shaft will turn freely, but without play.

If no shims are used the adjustment may be made by placing the bearing cap in a vise and draw-filing straight across both edges with a fine toothed double-cut file. If the work is properly done each side of the cap will be lowered evenly with the other. Should the shaft bind after replacing the cap and tightening the bolts, two thin shims should be made and one placed on each side.

The best fit will be secured by removing shims or filing and then finishing the fitting by scraping the bearing to a good fit. With the cap and liner removed, some form of color, such as Prussian blue, should be applied in a thin even coat to the shaft surface. The cap should then be replaced and the bolts tightened. The shaft should now be turned once around and the cap removed. Wherever the color has been rubbed onto the inner surface of the bearing liner the liner metal should be removed by scraping the high spot or surface thus indicated. After scraping, the shaft is again covered with the color, is turned once around and the process repeated until at least two thirds of the entire inner surface of the liner shows the color.

The handle of the bearing scraper should be held rather loosely with the fingers of one hand and laid lengthwise of the bearing liner so that two edges of the scraper rest on the bearing metal. The scraper blade can then be lightly pressed against the liner metal with the fingers of the other hand, when, by moving the blade, a thin layer of metal can be removed.

Bearing, Plain, Clearance for. In fitting plain bearings the following radial clearances should be allowed:

Connecting rod lower end, .002″.
Connecting rod lower end, forked, .003″.
Crankshaft main bearings, .002″ to .004″.
Piston pin bushings, .002″.

End play should be allowed as follows:

Connecting rod lower end, .004″.
For main bearing that takes end thrust (rear or center) allow .004″ to .006″.
For bearings next to one taking thrust allow .015″ more than for the thrust bearing.
For bearings second from one taking thrust, .030″ more than for thrust bearing.

Bearing, Roller. A form of bearing used in a large number of cars of all types is that known as the roller. This form is made in three distinct types, one of which is known as the taper roller, another one the solid straight roller, and the third one the flexible roller.

The taper roller bearing, Fig. 46, is composed of an inner and outer race, the inner race being

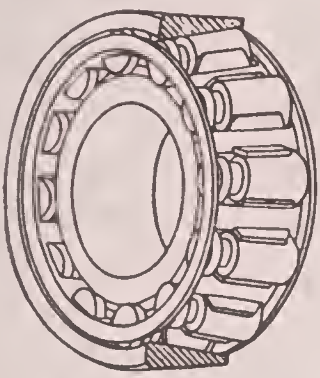


Fig. 46
Taper Roller Bearing

designed to fit over the shaft and the outer one being carried by the bearing housing. The outer surface of the inner race is conical in form and the inner surface of the outer race is of a form to correspond, that is, its internal diameter is smaller at one side than at the other. Between the two races is carried a series of steel rolls, each one of which is tapered so that it fits between, and bears along its entire length on both races. This forms a bearing of anti-friction qualities similar to the annular ball, with the exception that the contact between the rolling members and their supports is a line rather than a point. It is customary to maintain a predetermined distance between the separate rolls by providing cages into which the rolls fit loosely. It will be seen that because of the tapered formation it would be impossible to press the inner race hard enough to cause it to pass completely through the outer race with the rolls in place, while in the other direction the inner race would drop out because of its own weight. This feature allows the tapered roller bearing to withstand a large amount of end thrust when this thrust is applied on one side of the bearing only.

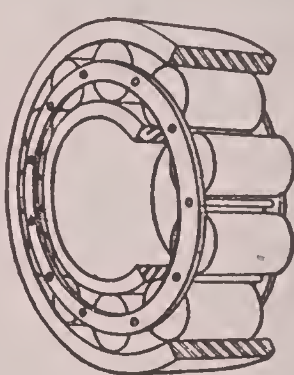


Fig. 47
Straight Solid Roller Bearing

Roller bearings are made of an inner and outer race with both surfaces of each race truly cylindrical, Fig. 47, and between these races is carried a series of straight cylindrical rolls. With plain rolls in use, the bearing will not withstand any end thrust because of the fact that the races and rollers will move freely over

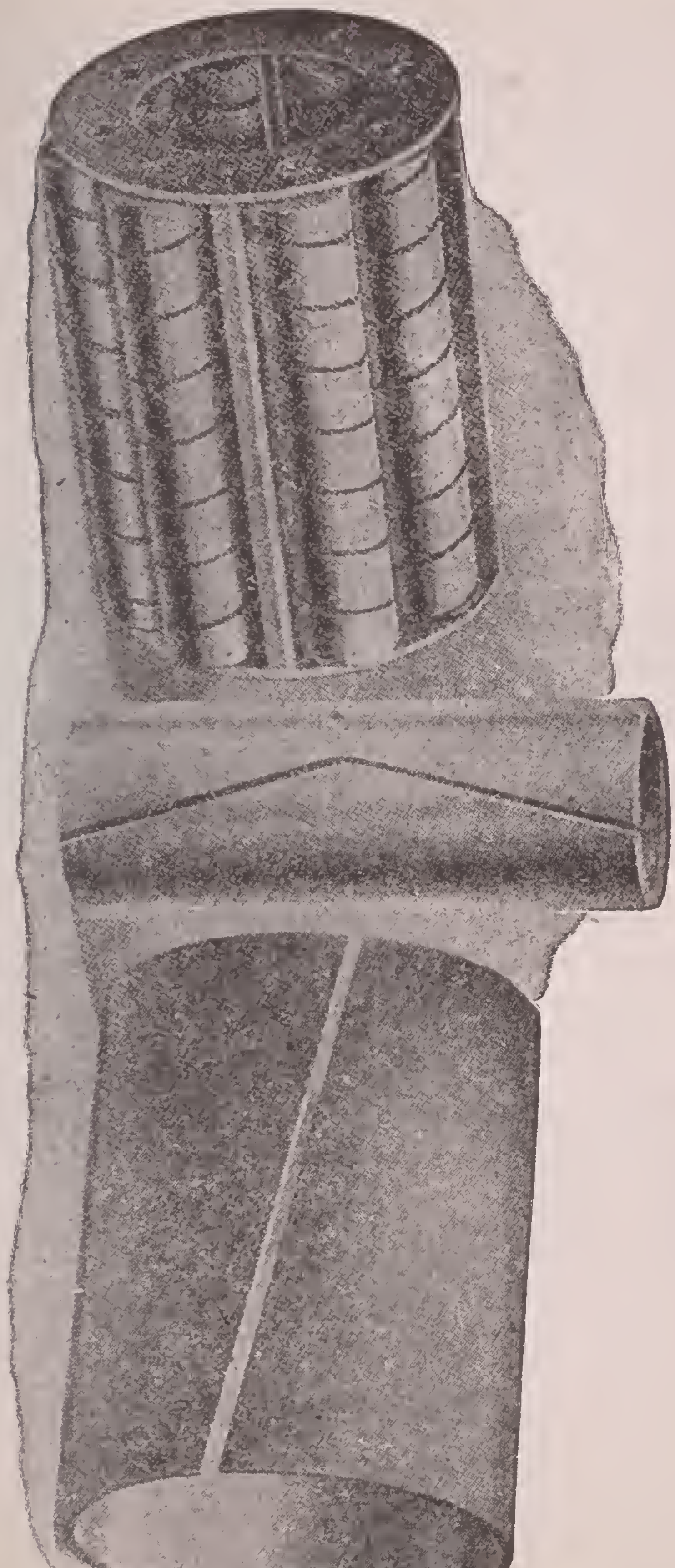


Fig. 48
Hyatt Self-Oiling Self-Contained Roller Bearing

each other in the direction of their axes. When it is desired to have this type of bearing withstand a thrust load, one or both of the races must be made with either a ridge or a groove at or near one edge and the rolls must then have a corresponding ridge or groove to engage the race.

The flexible roller bearing is made by the Hyatt Roller Bearing Co. and consists of two races, each of which is tubular or cylindrical in form, and between these races is carried a series of rollers, as in other types previously described, differing in that the rolls are formed from a piece of comparatively thin flat steel twisted into a spiral. It is from the springiness of this form of spiral roller that the bearing takes its name, "Flexible."

The load capacities of Hyatt roller bearings in sizes having the same outside dimensions as annular ball bearings of the same number are as follows at 500 revolutions per minute:

Bearing Number	Pounds	Bearing Number	Pounds	Bearing Number	Pounds
307	1,855	312	4,750	317	10,400
308	2,050	313	5,570	318	11,000
309	2,520	314	6,900	319	12,300
310	3,450	315	7,920	320	14,200
311	4,170	316	8,775		

Bendix Drive. The Bendix drive, Fig. 49, consists of a solid or hollow shaft having screw threads on the outside, and a hollow gear having screw threads on the inside, so that the gear screws on the shaft like a nut on a bolt. A circular weight is fastened to the gear, and is slightly out of balance. A coil spring connects the electric motor shaft and the hollow screw shaft.

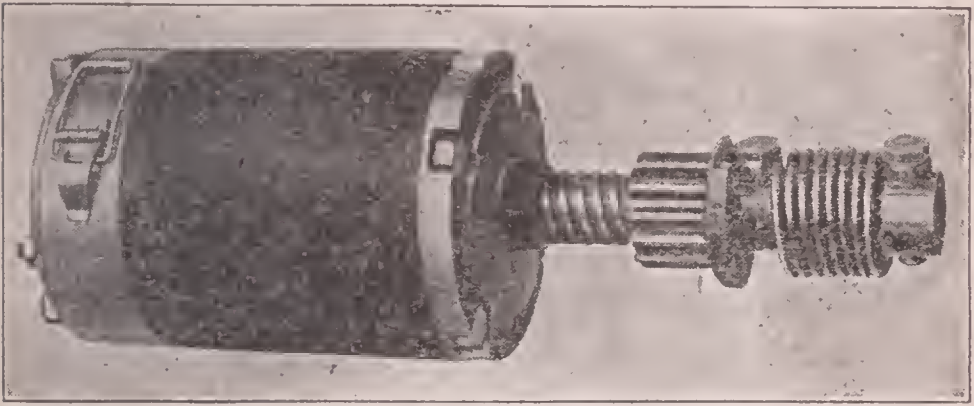


Fig. 49
Starting Motor With Bendix Drive

When the electric motor starts it drives through the spring and turns the screw shaft. Because of the weight, the gear is too heavy to turn with the screw shaft, and because the gear does not turn it must move along the screw shaft (just the same as if you turned a bolt having a nut on it, and kept holding the nut with your fingers to keep it from turning so that it would be screwed along the bolt). After the screw gear has moved along the screw shaft and engages with the flywheel gear it then keeps on moving along until it reaches the stop at the end of the screw shaft. The two gears then are fully meshed, and it is obvious that when the screw gear has reached the stop it cannot move any farther, and it then must turn with the screw shaft. At this particular moment the screw shaft and electric motor are revolving at a great speed, and this great blow and the power of the electric motor are both taken through the coil spring. The spring keeps coiling until all this power has been applied to the flywheel gear and the engine starts turning.

As soon as the engine starts exploding and runs under its own power, the flywheel of course turns much faster than it was cranked by the starter. Because it is now turning so much faster it increases the speed of the screw gear so that the latter runs faster than the screw shaft on which it is mounted. It is therefore plain that if the screw gear runs faster than the screw shaft, that it will be screwed on the threads of the shaft (like a nut on a bolt) until it has been screwed out of mesh with the flywheel gear. This demeshing movement is entirely automatic and eliminates the use of an overrunning clutch. And now that the screw gear is out of mesh it is natural to suppose if the electric motor keeps running that the gear will be automatically screwed right back into the mesh with the flywheel gear. But the unbalanced weight on the screw gear performs its automatic function. That is, being slightly out of balance, the weight twists or cocks the screw gear so that it clutches and binds on the screw shaft and turns with it. This automatic clutching is all due to the centrifugal force of the unbalanced weight.

When the electric motor stops running, the screw gear has been fully screwed away from the flywheel gear, and it remains in that retarded position until it is again required to start the engine.

The screw shaft should never be oiled or lubricated. It is not necessary and, in fact, the screw gear works to the best advantage when the screw shaft is dry.

Through accident or otherwise, should the flywheel ever be entirely exposed and unprotected, and should the gear tend to stick on the shaft, it may then be necessary to clean the screw.

The teeth on the screw gear and flywheel are chamfered or pointed on only one side to make the meshing natural and easy. However, should the teeth meet, end to end, the screw shaft itself is designed to move automatically backwards, against and compress the coil spring. This gives the screw gear time enough to turn and enter the flywheel gear. Should sticking of gears ever occur, they can be released by throwing in the clutch and moving the car. Such trouble would be due to incorrect chamfering or inaccurate alignment of the gears. Also it might be due to the binding of the drive parts and prevent compressing and proper functioning. Such defects should be corrected.

If while the engine is running, the electric motor should be accidentally started, the screw gear will of course screw over against the turning flywheel gear. But instead of the clashing and smashing of gears that might be expected there is no damage whatsoever, as the gears simply touch once. This is because the flywheel gear will speed up the screw gear, and thus automatically screw it away. The turning screw gear will then automatically clutch and bind on the screw shaft, in exactly the same manner as when it is cranking and has been demeshed when the engine starts exploding.

Bodies. In the construction of automobile bodies the sills are made strong, and the superwork is rendered independent of the actual structural strains. Wood is generally used in the framing, although it is sometimes replaced by cast aluminum.

When wood is used for framing, sheet aluminum, steel and thin layers of wood are employed. The aluminum is laid on a form and beaten to the shape required for the panel. The steel sheets are die formed, while the wood is made flexible in order that it may be bent to its proper shape when fastened to the body. In order to have the car of light weight, all body builders use the lightest materials possible in the construction of that portion which lies above the chassis.

When aluminum is used in the panels and for facings, care must be exercised to prevent water from creeping in between the metal and the framing, because water causes an electrolytic action on the aluminum plates. To prevent the oxidation of sheet steel, the plates are either coated with aluminum or zinc, or they are given a priming coat of paint on the inside.

As a general thing, putty is not used in the construction of bodies, as there are few joints which require it. In the very best body painting twenty coats are used before the paint assumes its proper finish. The first coat, or priming coat, generally consists of pure white lead mixed in oil. After that the second priming coat is given to it, and from then on the number of coats of rough paint will depend upon the nature of the surface and the degree of finish. For a very fine finish, the last coats consist of varnish, but when wagon finish is desired, the last coats consist of paint.

Finishers must take into account the fact that all cars are more or less abused in service, and it is to be expected that the magnificently equipped limousine will have a somewhat finer finish than the hard used touring car.

Classification of Bodies. Besides being classified according to the type of gasoline engine, methods of transmission, number of cylinders, etc., automobiles are also classified according to the type of body which is mounted on the chassis. While there are a considerable number of names which are given to the same types of pleasure automobiles, they may be generally classified as runabouts, roadsters, tourabouts, touring cars, town cars or taxicabs, landaulets, limousines and semi-limousines. Electric automobiles are generally divided into coupes, brougham, stanhopes, runabouts, phaetons, etc. Steam cars follow the same general classification as gasoline machines. Commercial vehicles may be classified as taxicabs, delivery wagons, trucks, busses, wagonettes, ambulances, patrol wagons and other forms for fire service.

Commercial Vehicles. In the commercial vehicle field steam, electric and gasoline machines are used. Electric vehicles are used for certain purposes, from heavy trucks to light delivery wagons, usually only for short distances. Steam power is not at present being used to any extent for heavy trucks, while the gasoline commercial is used for trucks, business wagons and quick deliveries.

The commercial vehicle may be classed as follows: Taxicabs, general delivery, light trucks, heavy trucks, coal wagons, sight-seeing cars, busses, ambulances and particular other types for special purposes.

Since, for general purposes, the speed of commercial vehicles is small, they are not necessarily equipped with high power, as a heavy car, which would travel at a high speed, would be apt to be dangerous. The speeds obtainable range on an average between twenty miles per hour for delivery wagons, to five miles per hour for heavy trucks.

While there are many distinct types of car bodies, there are more names in use than there are bodies, because different makers often apply different names to the same type of body, and often list a certain type of body under a name different from the one ordinarily accepted. This practice makes it difficult to state positively that a certain type of body will be called by a given name by a maker although that particular body is of its own distinctive type regardless of the name applied in the catalogues.

Bodies may be classified according to the number of persons carried, whether they are wholly or partly enclosed and according to the purpose

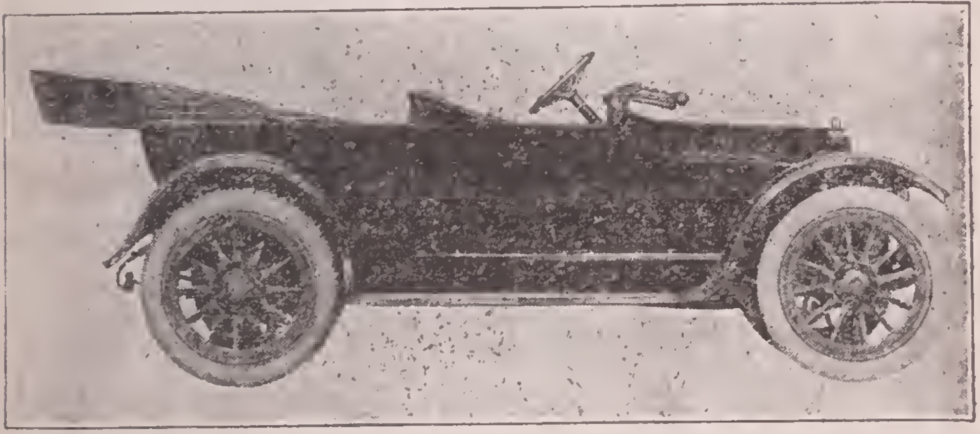


Fig. 50
Five-Passenger Touring Car

for which they are designed. None of these divisions is very satisfactory, because some types would appear in more than one division. The following definitions are those generally accepted.

Touring Car. This is an open car, Figs. 50 and 51, for general purposes which may seat four, five, six or seven persons, including the driver. It has sides and doors, but when protection from the weather is desired the operator uses a folding top and curtains.

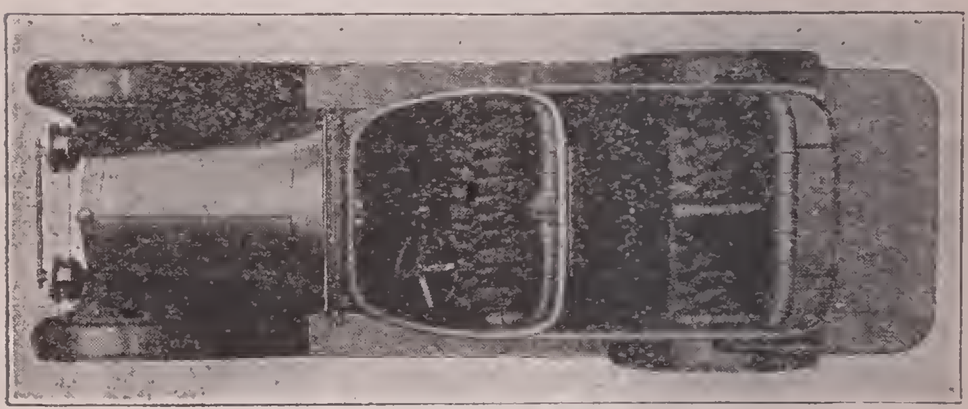


Fig. 51
Seating Arrangement in Four-Passenger Car

A touring car seating five is called a five-passenger touring car, one seating seven is called a seven-passenger touring car, and so on for any number of passengers. The rear compartment of a touring car is called a tonneau, the front compartment is called the driver's compartment.

Close-Coupled or Toy Tonneau. A four-passenger touring car with the rear seat brought well forward is sometimes called by one of these names.

Torpedo. This is a touring car having the body as small and low as possible while seating the number of passengers desired. The body is of a form that offers the least resistance to wind pressure and is called "stream line" in shape.

RUNABOUT. This is an open body seating two passengers, mounted on a comparatively small, light or low powered chassis for use in town and city travel and short country trips.

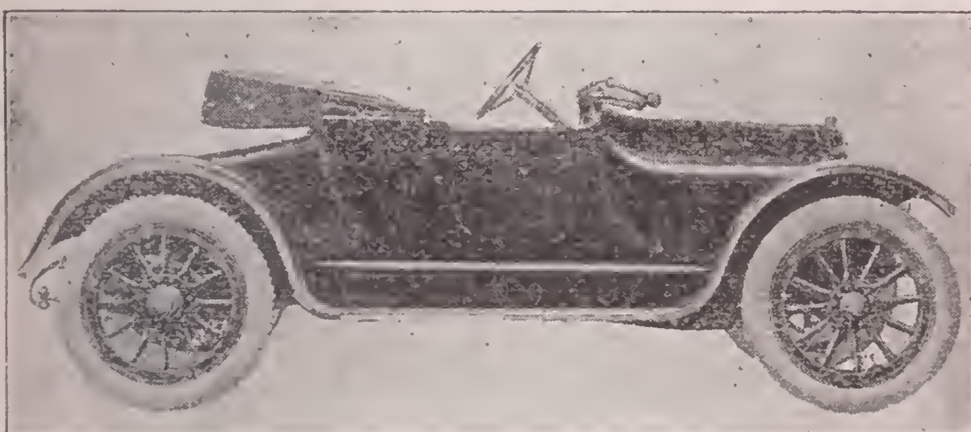


Fig. 52
Two-Passenger Roadster

ROADSTER. This is also an open body, Fig. 52, seating two passengers, but mounted on a chassis whose size, weight and power fits it for heavy work and long distance touring.

SPEEDSTER OR RACEABOUT. This is a powerful chassis carrying small, light seats for two passengers and designed for high speed work. The body is made as small and light as possible with "bucket" seats, floor, dash, gasoline and oil tanks, but no sides or doors, and in most cases without a top.

LIMOUSINE. This is a type of body, Fig. 53, used mostly for town and city driving in bad weather or during the cold season.

It seats four, five, six or seven persons in addition to the driver. It has a permanent top and the rear compartment is entirely enclosed and has full doors. The driver's compartment is di-

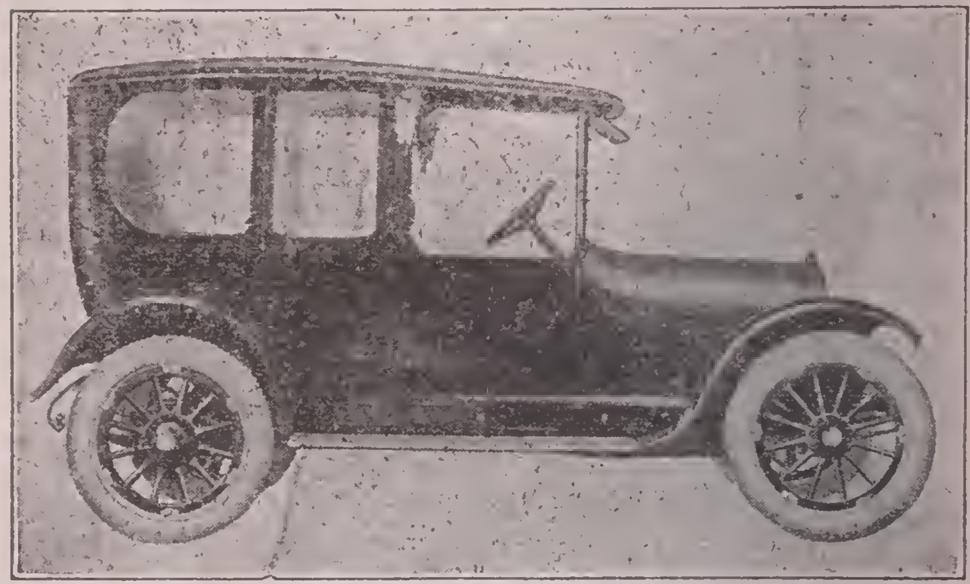


Fig. 53
Limousine Body

vided from the rear by a partition and this compartment is only partly enclosed.

Berline or Berlin. This type is exactly like the limousine except that the driver's compartment is fully enclosed and has full doors.

Sedan. This body is like the Berline, that is to say, fully enclosed, but there is no partition between the driver's and rear compartment.

Landaulet or Landau. This is a limousine which has the rear half of the passenger compartment closed with a top that is rigid when raised but that lets down like those tops of closed carriages in common use.

Town Car. This type has the rear compartment entirely enclosed with full doors, and seats four or five persons in this part of the car. The driver's compartment is open, the same as in a touring car. The driver may be protected by a small canopy extending forward from the enclosed portion.

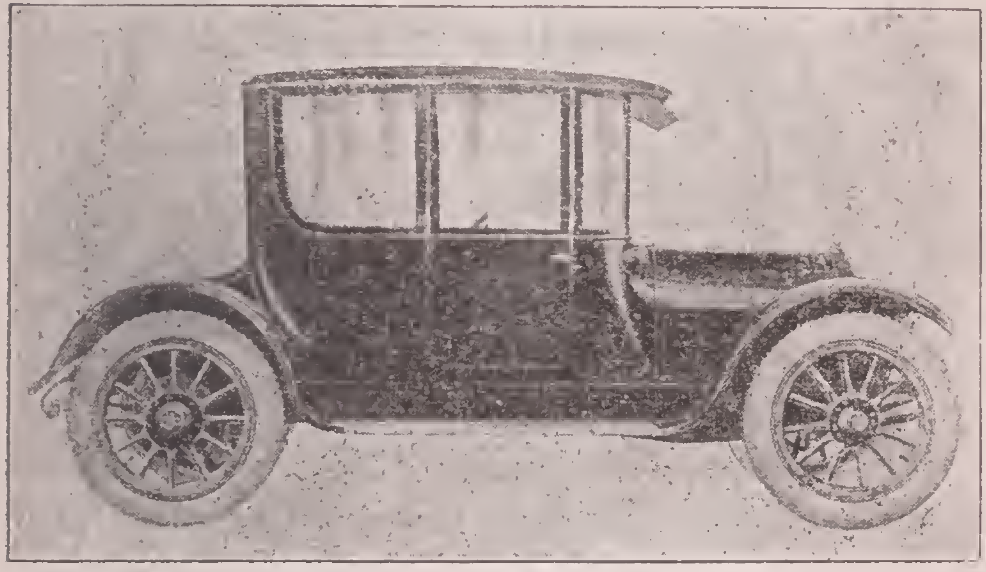


Fig. 54
Coupe

Coupe. This type of body, Fig. 54, is entirely enclosed and has full doors. It may seat two, three or four passengers in the enclosed part, the driver being one of these. It is mounted on a roadster chassis and bears the same relation to the roadster that the Sedan bears to the touring car.

Convertible Coupe or Sedan. These bodies are built in such a way that they give exactly the same appearance as a regular Coupe or Sedan from either the outside or inside. The upper portion is removable so that the Coupe or Sedan is converted into a roadster or touring car, depending on the arrangement and number of passengers carried.

Cabriolet or Couplet. A convertible coupe may be called by either one of these names, both meaning the same thing.

Taxicab. A car used as a public vehicle and being for hire according to certain designated rates of fare is called a taxicab. It is fitted with a "taximeter" which records the distance traveled and the time spent in waiting, and automatically computes and indicates the fare to be paid.

Taxicabs may be made from limousines, landaulets or town cars, the landaulet being the type most generally used.

Commercial Car Bodies. These types include those used for carrying merchandise and also those used for carrying passengers as a business. Commercial car bodies may be designated according to the type of construction, the class of work to be handled or the weight to be carried.

Truck Bodies. These include the express, platform, stake and panel types, and also many special designs. Truck bodies are usually made from designs prepared for each individual job and according to the customer's requirements, except in the lower priced cars.

Passenger Bodies. These include taxicabs, sight seeing cars, carrying from eight to twenty persons, and closed bodies suitable for carrying passengers and baggage in interurban work.

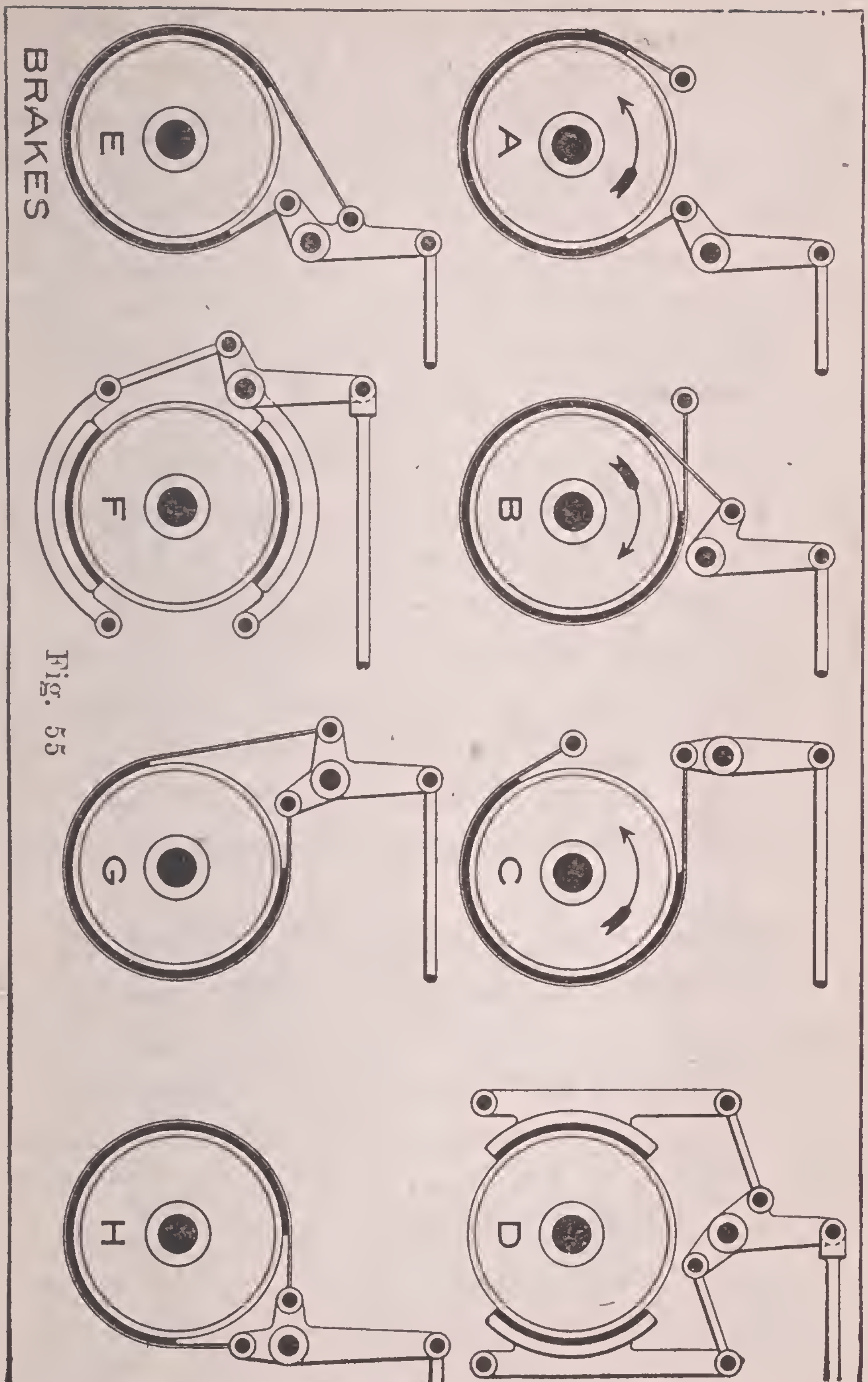


Fig. 55

Brakes. A brake is a mechanism which is a necessary part of the machinery of an automobile and enables the operator by exerting a slight amount of force on a lever to reduce the momentum of the moving car. Brakes used on automobiles may be divided into three classes: Hub or rear wheel brakes, transmission and differential gear brakes. Brakes have also been applied to the tires of the rear wheels, but have proved unsatisfactory and have been abandoned. The forms of brakes in use are single, or double-acting, foot or hand operated, and of the band, block or expanding ring types.

Figure 55, at A, B and C, shows three forms of the simplest type of single-acting band-brake. This type of brake can only be operated successfully with the brake wheel running in one direction only, which is indicated by the arrows in the drawing. If the brakes be operated in the reverse direction to that indicated by the arrows the result will be to jerk the lever or pedal out of the control of the operator of the car.

The three forms of band-brakes shown at A, B and C are all of the same principle, the difference being in the location of the fixed end of the brake-band and the shape of the operating lever. Type D is a form of double acting block-brake, which is designed with a view to eliminate any strain or side thrust upon the shaft of the brake wheel which may be caused by the braking action of the device. Types E, G and H are three types of double acting band-brakes, in which the brake may be applied with the brake wheel running in either direction.

Type F is a form of double acting block-brake, in which the right hand ends of the brake-shoe arms are pivoted to stationary supports, and the left hand ends connected together by means of a link and bell-crank lever as shown in the drawing.

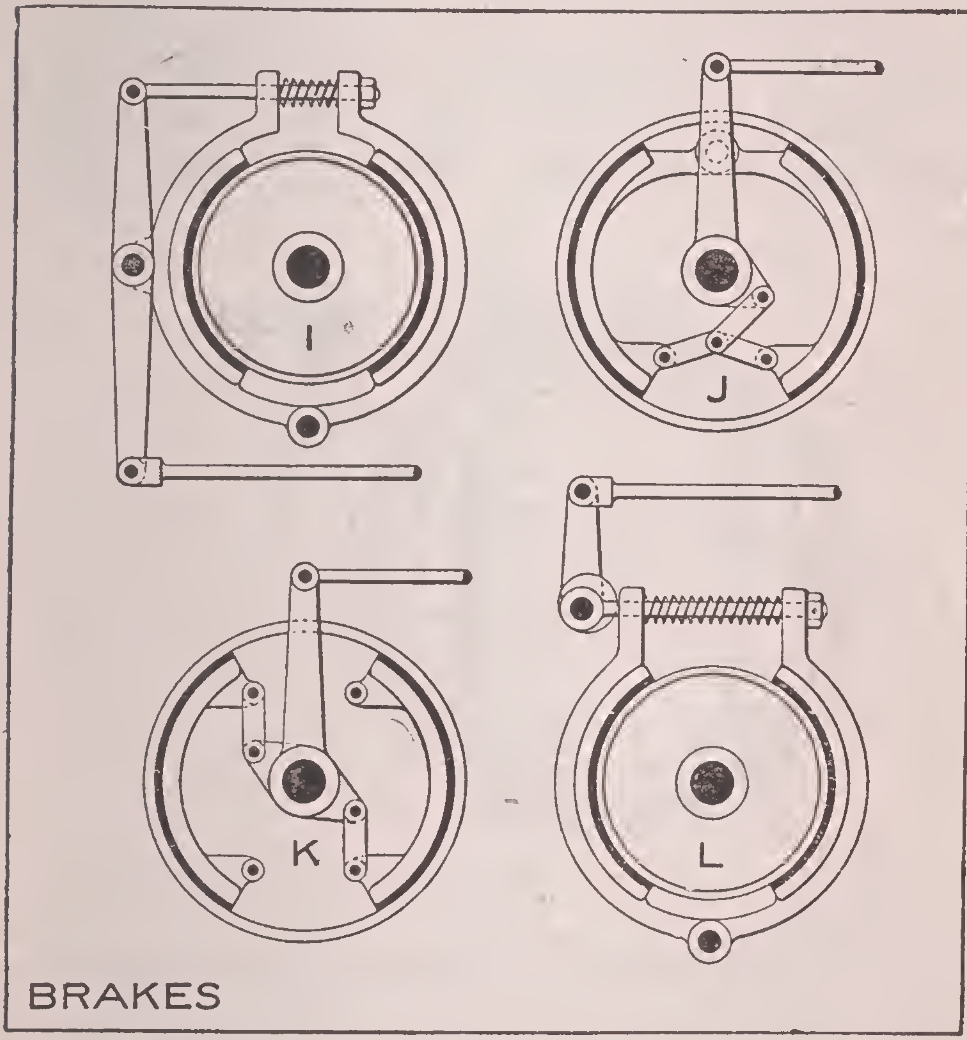


Fig. 56

In Figure 56 a form of double acting block-brake I is shown, which is extremely powerful on account of its peculiar construction, in that is has a double leverage upon the brake wheel, which may be readily seen by reference to the drawing. Types J and K are of the form known as internal brakes and of the expanding ring type, the brakes operating upon the inner surface or periphery of the brake wheel, instead of the outside. They are known as hub brakes, being usually attached to the hubs of the rear wheels of the car. Type L shows a form of block-brake in which the pivoted brake arms are drawn together by the eccentric located on the brake lever shaft. When the lever is re-

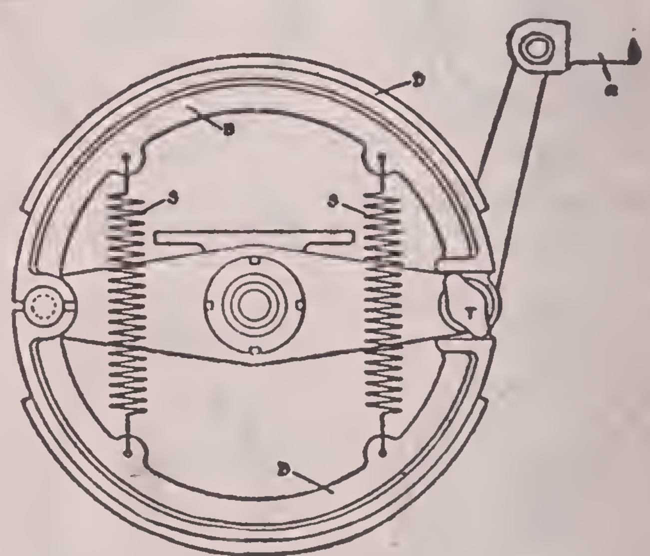


Fig. 57

leased the brake-shoe arms are forced apart by the action of the coil spring between the upper ends of the arms.

Expanding Brake. In the internally expanding brake, Figure 57, a hollow metal drum or pulley D is carried upon some continuously revolving portion of the car mechanism, and within this drum are supported two metallic shoes B B, which conform in shape to the inside surface of the drum by means of a spring, S S. The shoes are capable of being strongly pressed against the revolving inner surface of the drum by means of a cam or toggle arrangement, T, operated through a wire rope or metal rod, R, from the operator's lever or pedal. It is important that brakes of both these types should have their bands or shoes so arranged that an equal frictional effect is produced upon their drums for a given force applied by the operator,

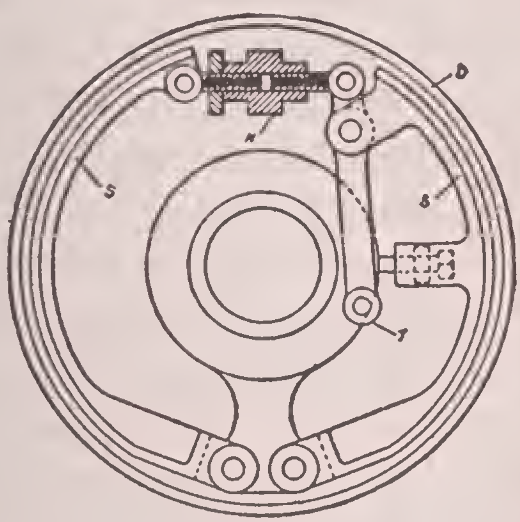


Fig. 58
Expanding Brake

whether the vehicle is running forward or backward. A brake so arranged is said to be double acting.

Brake Linings. For expanding brakes, metal shoes have become standard, owing to the practicability of maintaining proper lubrication between the frictional surfaces. In external brakes the metal band is provided with some form of nonmetallic lining that forms the braking surface applied to the drum. The reason for this is that it is practically impossible to properly lubricate an external brake. Various kinds of material, viz., leather fabric, asbestos, vulcanized fibre and camel's hair belting, are used for lining external brake bands. A material which is used for this purpose must have great resisting powers, a constant co-efficient of friction, even in the presence of oil and water, and it must have the ability to resist the influence of heat due to the brake's action. In practice it has been found that leather lined brakes burn out, and fibre linings become brittle and cannot be depended upon, so that inorganic materials, which cannot be carbonized, such as asbestos fibre, are widely used. Asbestos fibre may be readily woven into a fabric which answers this requirement, but when used by itself its strength is not sufficient. When, however, it is woven over a metal wire gauze foundation it appears to have the necessary stability to withstand very severe service, and this is the method employed in manufacturing the incombustible brake linings which are being used.

Cork is the bark of the cork tree, and is the lightest known solid. Its weight is one-eleventh of aluminum, and one-thirtieth of cast-iron. It has a very high co-efficient of friction, and is not affected by many of the conditions which seriously impair the efficiency of other substances.

Cork possesses qualities which distinguish it from all other solids, namely, its power of altering its volume to a very marked degree in consequence of à change of pressure. It consists, practically of an aggregation of minute air vessels, having thin, water-tight, and very strong walls, hence, if compressed, the resistance to compression rises in a manner more like the resistance of a gas, for instance, than to that of an elastic solid, such as a spring. The elasticity of cork has a wide range and is very persistent. It is this elasticity which makes it valuable when used as an insert in a metal shoe. Cork is of rather a brittle nature, though extremely strong, and for that reason it cannot be used in the form of a lining or facing. The method of applica-cation is to insert corks in holes in the brake provided for the purpose. Cork is not particularly affected by heat or oil, and will largely increase the efficiency in any application to a brake or clutch.

Where metal-to-metal surfaces, with or without cork inserts, are used, the surfaces are usually of different materials. The most common material for drums in all cases is steel, but that of shoes is either malleable cast iron, brass or a bronze. Different metals make a better wearing surface, and some combinations will have a higher degree of friction adhesion than others.

In the selection of material for brake linings, the co-efficient of friction is an important factor to be considered. Table 7 gives the relative values existing in combinations of different materials.

TABLE 7.

Material—	Co-efficient of friction
Metal to Wood	0.25 to 0.50
Metal to Fibre	0.27 to 0.60
Metal to Leather	0.30 to 0.60
Metal to Metal	0.15 to 0.30
Metal to Cork	0.36 to 0.65

EQUALIZERS. In connection with all brakes which are used in pairs, some method is used to equalize the pressure of the brake handle or foot pedal so that the same pressure will be applied

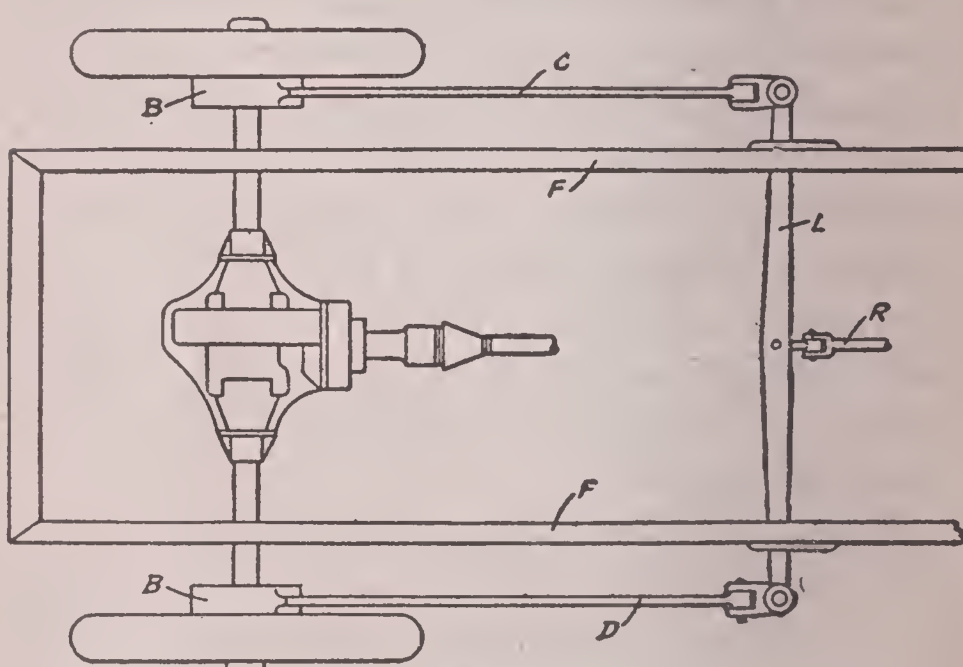


Fig. 59
Floating Lever Type of Equalizer

to both brakes. If the power is not equally applied to each brake, side slip or "skidding" will result.

The different methods of equalizing brakes are shown in Figs. 59, 60, 61 and 62, the majority of cars using what is known as the floating lever type, the cable arrangement being used only on several makes of cars. The floating lever type of equalizer is illustrated in Fig. 59. L is the floating lever, connected at its central point to the brake lever, or pedal by means of rod R. The ends of lever L are connected to the brakes B, B, by means of the brake rods C and D. When rod R is drawn forward, lever L draws rods C and D forward thus giving an equal pressure on the hub brakes.

Fig. 60 shows another type of floating lever equalizer. Shaft S connects to the brakes by

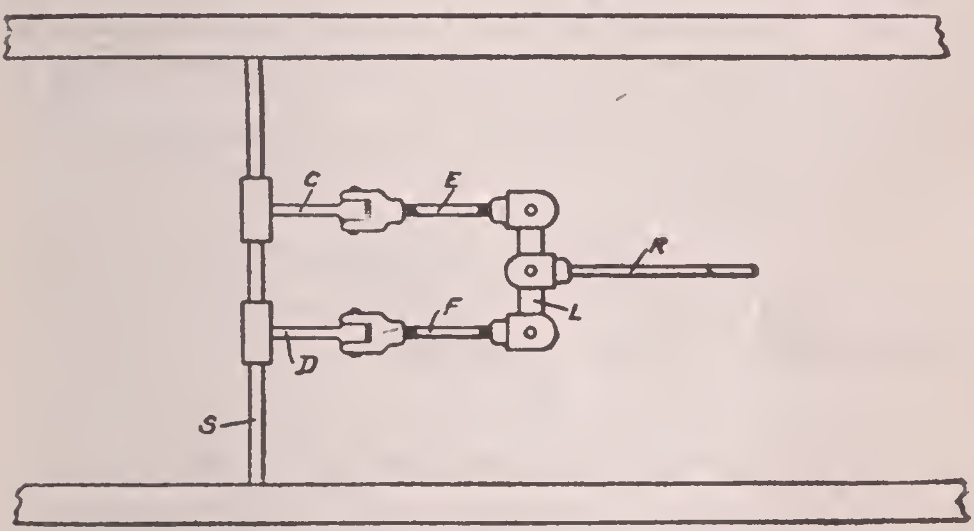


Fig. 60
Floating Lever Equalizer

means of rocker arms located just outside the frame. Two rocker arms, C and D are connected to shaft S, and to the equalizing lever L by means of rods E and F. In some cases the equalizing lever is located outside of the frame. It then takes the form shown in Fig. 61, in which L is the lever that equalizes the pressure on both brakes connected to shaft S. Fig. 62 shows the arrangement of the cord equalizer. Shaft S is connected to the two brakes, one at each end, and it has two rockers, or cranks E and F attached to it. Parallel to S is another shaft C, which carries a grooved roller R. A cable is connected to crank E, carried over R, and then passing back, is connected to crank F. When R is moved in the direction of the arrow, by the brake lever, the cord distributes the tension between E and F, and as a consequence the brake also. This type is much cheaper than the others, but it requires more care and attention.

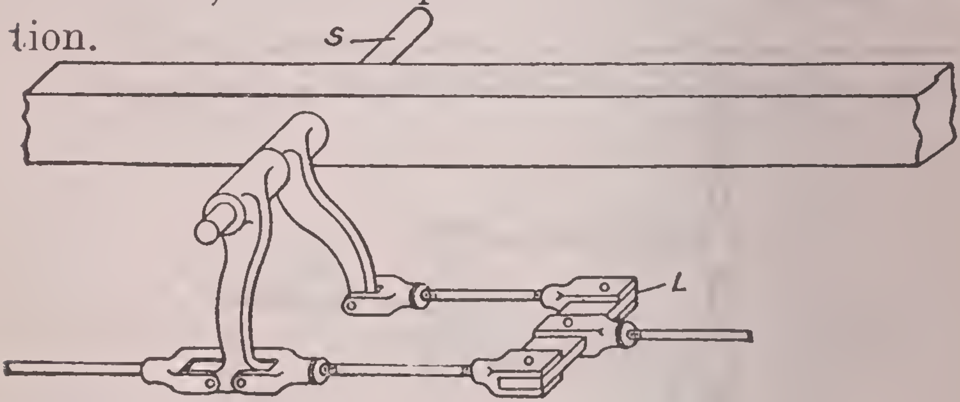


Fig. 61
Equalizer Lever Outside the Frame

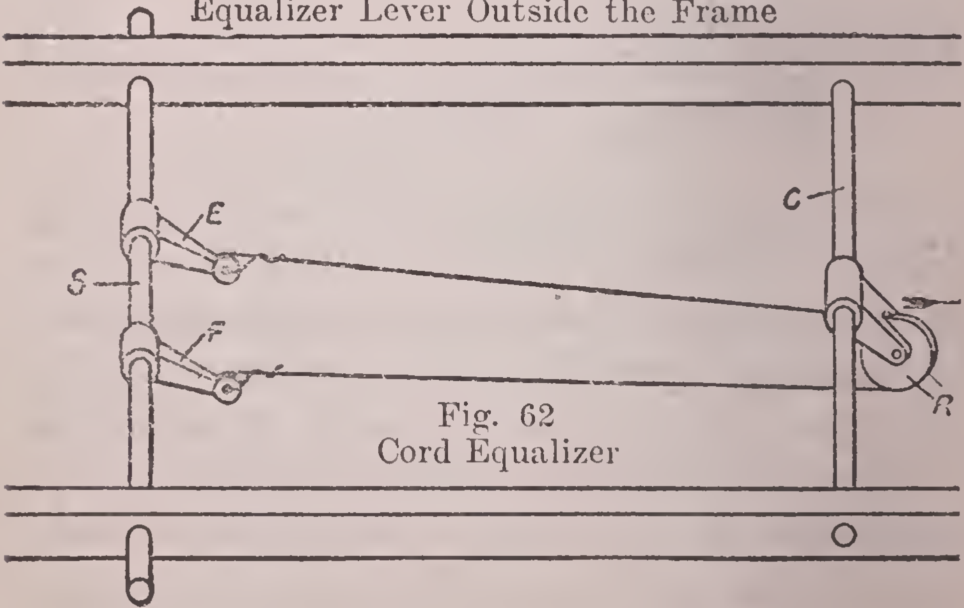


Fig. 62
Cord Equalizer

Brazing. Many workmen labor under the impression that a brazing job cannot be done unless the parts are a loose fit, in order, as they say, to allow the brazing material to enter and form a bond. The result is, when they do the work, the parts are a very loose fit, with accentuated shearing tendencies in the section of the brazing material, and if the brazing happens to be poorly done, the result is anything but good, since, in the absence of brazing, there is not even a good mechanical bond.

A good mechanical bond is possible to procure without, in any way, interfering with the brazing process, since the parts, if they are well fluxed, will take a coat of brazing material, even when the recess is but a thousandth or two. In brazing, if the work is to be up to a sufficient standard to use in steering gear, it is necessary to clean and brighten the surfaces in a most thorough manner. This will best follow by mechanical scraping rather than by dipping in some corroding material. Dipping may be of value as a preliminary, but a file, and scraper, in the hands of a man of competence, will go a long ways toward success.

When the parts are well brightened, and the grease is thoroughly removed, by the use of soda water, benzine, or equally good solvents, it remains to flux the parts with borax, and then apply the heat, either by a forge or from a special form of brazing torch which uses gasoline, kerosene, or other fuel oil, to produce the necessary heat. All forms of burners have means of adjusting the flame, and two or more burners are usually placed in such position that their flames strike the work. Torches are similar to the Bunsen burner; if fire brick, or clay, is used to build up around the parts, the heating process will be attended with less difficulty, and the work will be better at the finish. A rather hard brazing material may be used. This may be purchased ready for use, and there is no reason at all why a motorist of even slight skill cannot make a good job of brazing.

Brazing Methods. The brazing flame must be so adjusted that no soot is deposited on the work and care should be exercised that no foreign matter of any kind enters between the surfaces to be joined.

But a single tool is required in brazing, this being a spatula formed by flattening one end of a steel rod which is from one-quarter to three-eighths inch in diameter. This spatula is used for placing the spelter, or brazing metal, on the work and for handling the flux.

Spelter, the metal used to make the joint, is variously composed of alloys containing copper, zinc, tin and antimony. Hard spelter, melting at about 1650° Fahrenheit is used with cast or malleable iron and with steel. A metal suitable for joining copper contains nearly equal parts of copper and zinc and melts at about 1400°. For fastening brass to iron and copper and for handling large pieces of brass to brass, a still softer spelter is used, containing two-thirds tin and one-third antimony.

The most generally used flux is pure calcined borax powder, this powder, mixed with about 15% of powdered sal ammoniac, making a satisfactory agent.

The surfaces to be brazed are thoroughly cleaned as already described and the parts are then placed in the relation to each other that they are to finally occupy. The work is then placed so that the melted spelter and flux will flow down into the joint and the work is braced or clamped in this position. It is advisable to place fire brick around the work to protect it from cooling draughts of air. The work is then well covered with flux, which is made into a paste with water, and the heat is applied until the flux boils and runs over the surfaces. Spelter is then placed in such a position that it will run into the joint and the heat is continued or increased until the spelter flows between the surfaces of the joint. The flame should surround the work so that air is excluded as far as possible.

Care should be exercised to avoid softening the metal in the work by too much heat, and when brazing two different metals together, the flame should be directed only on the one melting at the higher temperature, allowing the other metal to receive its heat from the one in the flame.

As soon as the spelter melts and flows, the heat should be removed. Should the spelter form into small globules instead of flowing, tapping the work will usually overcome the difficulty. If tapping does not produce the desired result, more flux, in dry form, may be added.

Carbon Deposit, Removal of. The outfit consists of a high pressure cylinder of oxygen gas with a reducing valve, pressure gauge, length of rubber hose, a shut off valve and a tube of flexible copper for introduction into the combustion space of the cylinders.

The shut off valve from the gasoline tank on the car should be closed and the engine run until it stops because of the exhaustion of the supply of gasoline in the lines and carburetor float bowl.

If the engine has "T" or "L" head cylinders, one of the valve caps should be removed. If the cylinders have overhead valves, remove the spark plug. In any case, should any spark plug then remain in the cylinder, it should be removed and replaced, during the operation, with an old one.

Having selected the cylinder to be cleaned first, raise its piston to the top center following the compression stroke so that both valves are tightly closed. In case the carbon has been burned hard the interior of the combustion space should then be wiped with a swab wet with kerosene until all of the carbon has been moistened.

The valve on the high pressure oxygen cylinder should then be opened, the shut off valve on the torch should also be opened, and the reducing valve handle screwed in until the low pressure gauge shows from two to three pounds. Then close the shut off cock and insert the end of the flexible tube into the cylinder.

Now open the shut off valve and introduce a lighted match or taper into the cylinder until the carbon starts to burn. Manipulate the end of the tube inside of the cylinder until all surfaces have been reached, taking special care with the valve pockets and other recesses. When the flame will no longer continue, despite movement of the tube, the burning has been completed.

In case the engine or dust pan is dirty or oily it will be well to protect the opening into the cylinder by means of sheets of asbestos or of thin sheet metal because there will probably be a considerable display of sparks which would ignite any exposed fuel or dirt which is oil soaked. It is also well to have a reliable fire extinguisher convenient to the hand of the operator during the operation.

Having completed the burning, the combustion space should be blown out with a blast of air from a compressor or from a hand bellows, thus removing the reminder of fine, dry carbon dust.

Lubricating oil is charged with the crime of depositing carbon on the surfaces of the combustion chamber, and this carbon in turn causes "bucking," and pre-ignition. It probably is true that inferior cylinder lubricating oil will deposit carbon, to some extent, but the main trouble is from the gasoline which will not vaporize until it is allowed to contact with the hot cylinder walls, and this process of reducing the gasoline to vapor is bound to lead to a carbon deposit for the same reason that wood is "coked" if it is heated to a temperature of about 650 deg. C., provided the amount of air present is less than that which would cause complete combustion.

PISTON HEAD SCRAPER. In most engines the piston heads can be scraped clean of carbon without removing the pistons from the cylinders, by means of specially formed scrapers introduced through the opening over the valves, or through the spark plug holes when the latter are horizontal. The form and size of scraper will depend on the particular engine, but almost any suitable form may be made from 5-16-inch steel tubing about 12 inches long having the ends hammered flat, and turned over at right angles in a vise. The ends are then filed straight, and sharp, and the shank of the scraper may be bent to right or left, if necessary, or left straight. Frequently two scrapers will be needed in order to use both right and left hand bends. The advantage of tubing for this purpose is that no blacksmith work is necessary.

Carburetors, Principles of. Internal combustion engines used for the propulsion of motor cars use gasoline for fuel in almost all cases. Experimenting is now going on in the endeavor to use kerosene or alcohol, and in some cases even lower grades of fuel. Gasoline and kerosene are secured by heating crude petroleum until vapor is given off, and this vapor is passed through pipes that are kept cool enough to condense the vapor into a liquid. Alcohol is secured by the distillation of fermented vegetable matter, and may be secured in almost any part of the country if suitable means for distillation were to be developed.

Before the gasoline is ready to burn in the engine cylinders, it must be turned into a gas or vapor. If gasoline stands exposed to the air it will vaporize at a comparatively slow rate, but if ejected from a small opening in a fine stream it will turn to vapor and mix with air much more rapidly. It is always necessary to mix the gasoline vapor with air in certain proportions to make a combustible mixture. The instrument that turns the gasoline into a gas and then mixes the gas with air is called the *carburetor* and the process is called *carbureting.*

Many forms of carburetors have been made and used, but all instruments now fitted are of the type known as automatic float feed. The spray nozzle is the small opening inside of the carburetor through which the liquid gasoline is drawn when it is to be made into a vapor.

The nozzle opening is placed in a tube through which the air must pass on its way to the engine cylinders. See Fig. 63. One end of this tube is open to the outside air and the other end attaches to the piping that goes to the engine cylinders. The end open to the air is called the primary air intake.

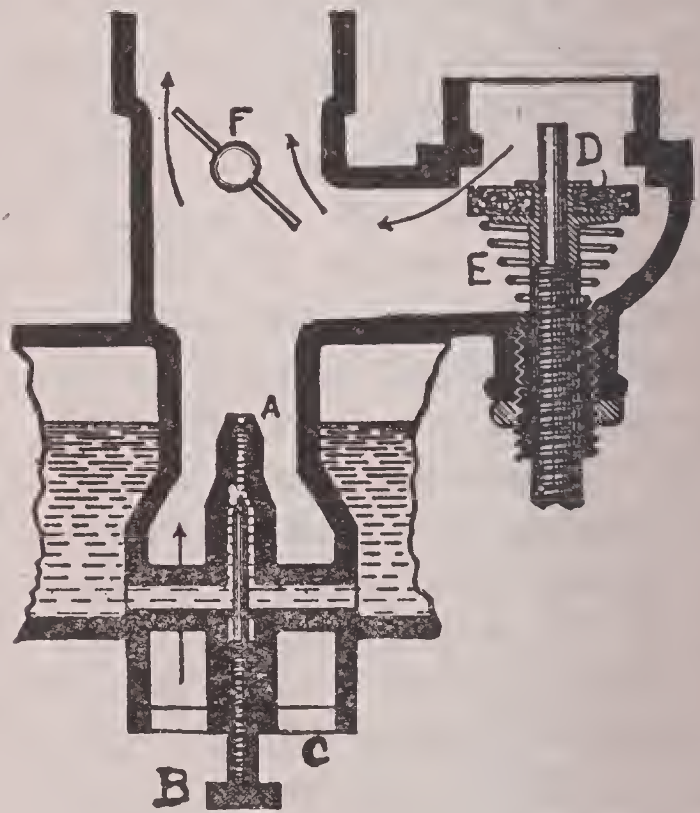


Fig. 63

Float-Feed Carburetor Mixing Chamber and Air Valve. A, Spray Nozzle. B, Adjusting Needle Valve. C, Primary Air Intake. D, Auxiliary Air Valve. E, Air Valve Spring. F, Throttle Valve.

When the piston travels away from the cylinder head on the inlet stroke, the inlet valve opens and a cylinder full of mixture is drawn from the carburetor. The air to make the mixture is drawn through the carburetor primary air intake and must pass by the nozzle opening. The gasoline is maintained at a height slightly below the nozzle opening, and the suction, or partial vacuum, of the incoming air causes some of the gasoline to be drawn out of the nozzle so that its spray mixes with the air. This is the principle on which all modern carburetors operate, but certain added features are necessary to compensate for the different conditions obtaining under different rates of car speed and engine load.

The first difficulty that would be encountered with the simple form of carburetor just described would be that of a falling gasoline level in the nozzle as the fuel was drawn into the engine. This would finally result in a failure of the fuel supply and stoppage of the engine. In actual practice, the gasoline from the car's tank does not pass directly into the nozzle, but goes first into a small tank on the carburetor, which tank is called the float chamber. Of the two openings in this small tank, one goes to the gasoline supply and the other communicates with the carburetor nozzle. Inside of the float chamber is a piece of cork covered with shellac or else a hollow metal cylinder, either of which will float on the surface of whatever gasoline may be in the chamber. At the opening of the pipe that comes into the float chamber from the gasoline tank is a small valve, Fig. 64, operated by connections attached to the float itself. When the float is low down in the chamber this valve is open; but as the float rises on the surface of the liquid coming from the tank, it finally reaches a height

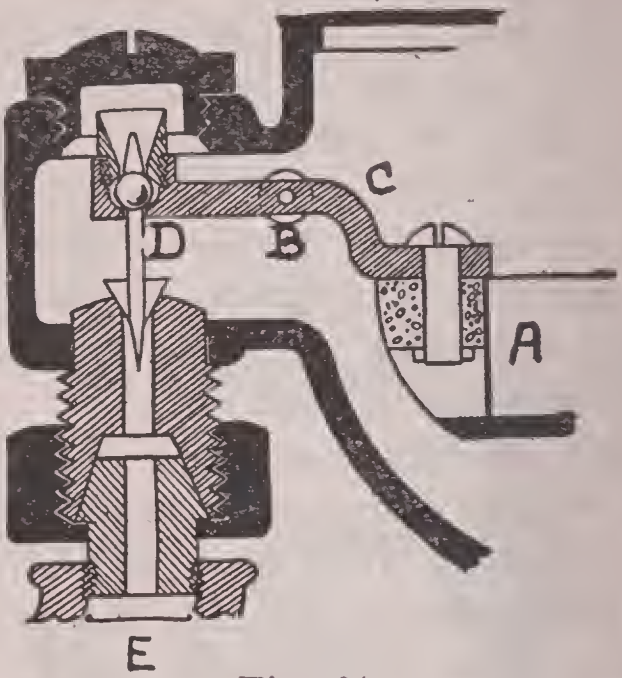


Fig. 64

Carburetor Float Valve Mechanism. A, Float. B, Float Lever Pivot. C, Float Lever. D, Float Valve. E, Gasoline Inlet.

at which the valve is closed, and it will therefore be seen that the level of the liquid cannot rise above the point determined by the position of the float when the valve closes. When gasoline is drawn from the float chamber, through the nozzle, the float falls with the fuel level until the valve is again opened, and by this repeated action the level is maintained constant.

Other parts of the carburetor, such as the auxiliary air valve, are described in the following pages and the construction and adjustment of the well known makes are taken up.

Almost any carburetor will give a reasonably good mixture through a limited range of action. Frequently, however, this range is found insufficient for a particular engine. If right for low speeds, it is wrong for high speeds, and vice versa.

The theory of carburetor action as regards the behavior of the gasoline jet under different air velocities is still only partially understood, and has been the subject of a great deal of more or less blind theorizing, based in many cases on wholly inadequate data.

A non-automatic spraying carburetor (i. e., a simple nozzle in an air tube) makes no mixture at all till the velocity of the air stream reaches a certain minimum. Beyond this point, the richness increases with the speed. Dilution from the auxiliary valve is therefore required only when the richness of the mixture exceeds the normal. At this point it should be remembered that, so far as the spray is concerned, there is no difference between a wide open throttle at slow engine speed (as for instance, up hill) and reduced throttle with high engine speed. The spraying action is concerned only with the velocity of the air past the nozzle before the throttle is reached.

Almost every carburetor is provided with the needle valve controlling the spray orifice. With this provision it is very easy to determine whether or not the carburetor is doing as well as it should at either low or high speed. For example, suppose we start with an adjustment known to be satisfactory for medium speeds. If the low speed performance is under suspicion, it is only necessary to increase the needle valve opening slightly to ascertain whether starting is thereby made easier, and a walking pace more smoothly maintained. If overheating results, reducing the needle opening will probably cure it. Similarly slight changes in the needle opening, without changing any other adjustment, will determine whether or not the mixture is improved by less, or more gasoline at high speed. When the carburetor is set for a medium speed, if the mixture is weak at low speeds, and rich at high speeds, more air should be admitted, but if the mixture is rich at low speeds, and weak at high, less air should be admitted. Much depends upon the spring.

It is a characteristic of all springs that their flexure is in direct proportion to the load imposed, up to the elastic limit of the spring.

THE FLOAT FEED CARBURETOR, always consists of two principal parts: a gasoline receptacle which contains a hollow metal or a cork float, suitably arranged to control the supply of gasoline from the tank or reservoir, and a tube or pipe in which is located a jet or nozzle in communication with the gasoline receptacle. This tube or pipe is called the mixing chamber. The gasoline level is maintained about one-sixteenth of an inch below the opening in the jet in the mixing chamber. The inductive action of the motor-piston creates a partial vacuum in the pipe leading from the mixing chamber of the carbureter to the motor, thereby causing the gasoline to flow from the jet and mixing with the air supply, to be drawn into the cylinder of the motor in the form of an explosive mixture.

SPRAYING CARBURETORS. In this type of carburetor the quantity of gasoline delivered is not proportional to the volume of air delivery at different rates of flow. This difficulty has, however, been met by providing a supplementary air inlet to the carbureter, which may be regulated by the driver at will.

Another method of correcting the variations in the proportions consists in providing a second spray nozzle. In the majority of cases in which multiple nozzle carburetors are used, there are two nozzles, practically two carbureters, a small one for idle running, and slow speeds, and a larger one for heavy work. In some instances, three, and even four nozzles are used.

In case an extra gasoline nozzle is used it is generally so placed that the suction has little or no effect upon it until a sufficient engine speed has been attained to cause the auxiliary air valve to open. The additional nozzle is placed in the stream of air from this auxiliary valve and the incoming air picks up a sufficient quantity of fuel to maintain the correct proportions of the mixture. This and other variations appear in the following pages.

Auxiliary Air-Valve. It has been determined from the result of experiments that to get the maximum power at any speed from a gasoline motor equipped with a float-feed carburetor, the jet of the carburetor must have a larger opening for low speeds than for high speeds. As this practice would require a very delicate adjustment it consequently becomes almost impracticable, because necessitating a constantly varying regulation for each fractional variation of speed of the motor. The difficulty may be obviated by the use of an auxiliary air-valve, located in the induction-pipe close to the inlet-valve of the motor.

The jet of the carburetor is set for the maximum quantity of gasoline at the slowest speed of the motor, and as the speed is increased the auxiliary air-valve comes into action and increases the supply of air passing through the carbureter, thereby reducing the suction or partial vacuum at this point, and maintaining a constant quality of mixture at all times.

The auxiliary air valve has been attached to a dash pot construction in many makes of modern carburetors. The dash pot may operate with air or with gasoline for its fluid, but in either case the purpose is to prevent sudden opening and closing of the valve or "fluttering." Such fluctuation is a cause of noise and also tends to destroy the proportions of the mixture.

Frequently it is observed that the intake to the carburetor is so restricted that noise issues, and a little further investigation in such cases will disclose, in all probability, that wire-drawing is one of the ills. It is not alone the noise that is objectionable in such cases; the power of the motor will be less, due to the restriction which has the effect of reducing the weight of mixture that enters into the cylinders, and the power of a motor is undoubtedly proportional to the weight of mixture that enters the cylinders, assuming, of course, that the same is in acceptable form, and that it is completely burned. True, there must be a depression in the carburetor in order that there will be a difference in pressure, so that gasoline will be sucked into the train of air; equally true, it is of the greatest importance to have the depression as low as possible in order that the power of the motor will be a maximum. If the depression is but slight, provided the carburetor is properly designed, the amount of fuel entrained will be adequate for the purpose. If, on the other hand, the depression is very large and holds considerable fuel, it will soon be found to be wasteful of the liquid.

With the low grades of fuel now in use, wire-drawing is very harmful, inasmuch as it tends to separate the gasoline from the air and causes the gasoline vapor to again become a liquid and deposit on the tubing walls.

EFFECT OF COLD ON GASOLINE. The temperature has a very marked effect on the rapidity with which gasoline vaporizes, and in cold weather it is necessary to supply heat to the carburetor.

The carburetor should preferably be jacketed, and it may be warmed either from the circulating water, or by taking a small quantity of the hot gases from the exhaust pipe. If water is used it should be taken from a point just beyond the discharge of the pump, and should be delivered to the return pipe from the engine jacket to the radiator.

Whether exhaust gases or water is used, the flow should be regulated by a cock, otherwise too much heat will be received in warm weather. When the carburetor is cold, the engine may be started by pouring warm water over it, care being taken not to let any portion of the water get into the gasoline through any aperture in the top. Another method of warming up the carbureter is to wring cloths out of hot water, and wrap them around it.

While it is not generally realized, the flow of gasoline through the nozzle is greatly influenced by the temperature of the liquid. Gasoline at very low temperatures, such as freezing, and slightly above, is reduced as much as 30% in volume of flow below the point reached when the liquid itself is warmed to between 65° and 80° Fahrenheit. This forms one more reason for jacket heating on all carburetors.

Carburetor Inspection. The float valve of the carburetor should be tested for leaks by opening the valve between it and the tank and looking for gasoline drip. If gasoline escapes, it may simply be because the float is set too high, so that it does not close the needle valve before gasoline issues from the spray nozzle. Or, it may be that the valve itself leaks.

At this stage, it is well to assume that the float is properly adjusted, and to begin by shutting off the main gasoline valve, and then unscrewing the washout plug below the needle valve. It may be found that dirt, waste, or a splinter of wood has got past the strainer, through which, presumably, the gasoline passes on its way to the float, and is lodged in the needle-valve opening. It may be of advantage to open the top of the float chamber, which can usually be done without disturbing other parts, and take out the float and needle valve. A little gasoline washed down through the needle-valve orifice will then generally carry away any dirt that may have clung to the valve when the plug was unscrewed. If the gasoline still drips when the parts are reassembled, the mixing chamber should be opened and the top of the spray nozzle examined to see if gasoline is escaping from it. An electric light should be used in making an examination of the carbureter, as, with any other illuminant, a fire might be started. The portable electric flashlights answer the purpose very well.

Occasionally a carburetor is found to be too large for the engine, or to have too large a spray orifice. The advice has been given in such a case to reduce the size of the spray orifice by lightly pening the top of it with a hammer. This is counsel of doubtful value, even if the hole be afterward reamed true, since it is manifest that the burr formed in the top of the orifice cannot possibly be deep enough to be at all regular in its form. It will almost inevitably throw a jet slantwise, instead of straight, and this jet failing to strike the main part of the air stream will be only partly atomized, with resulting misfiring and general bad behavior, especially at low speeds. If a new nozzle of smaller size cannot be substituted, the best thing to do in case there is no needle valve to adjust the flow of gasoline to the jet is probably, to warm the ingoing air as much as possible, in order to make evaporation by temperature take the place of atomizing due to the air's velocity.

HOLLY CARBURETOR, MODEL H. This carburetor is shown in Fig. 65. Before the fuel enters the float chamber it passes a strainer disk A which removes all foreign matter that might interfere with the seating of the float valve B under the action of the cork float and its lever C. Fuel passes from the float chamber, D, into the nozzle well E, through a passage F, drilled through the wall separating them. From the nozzle well the fuel enters the nozzle proper, G, through the hole H, and then rises past the needle valve I, to a level in its cup-shaped upper end, which just submerges the lower end of a small tube, J, which has its outlet at the edge of the throttle disk.

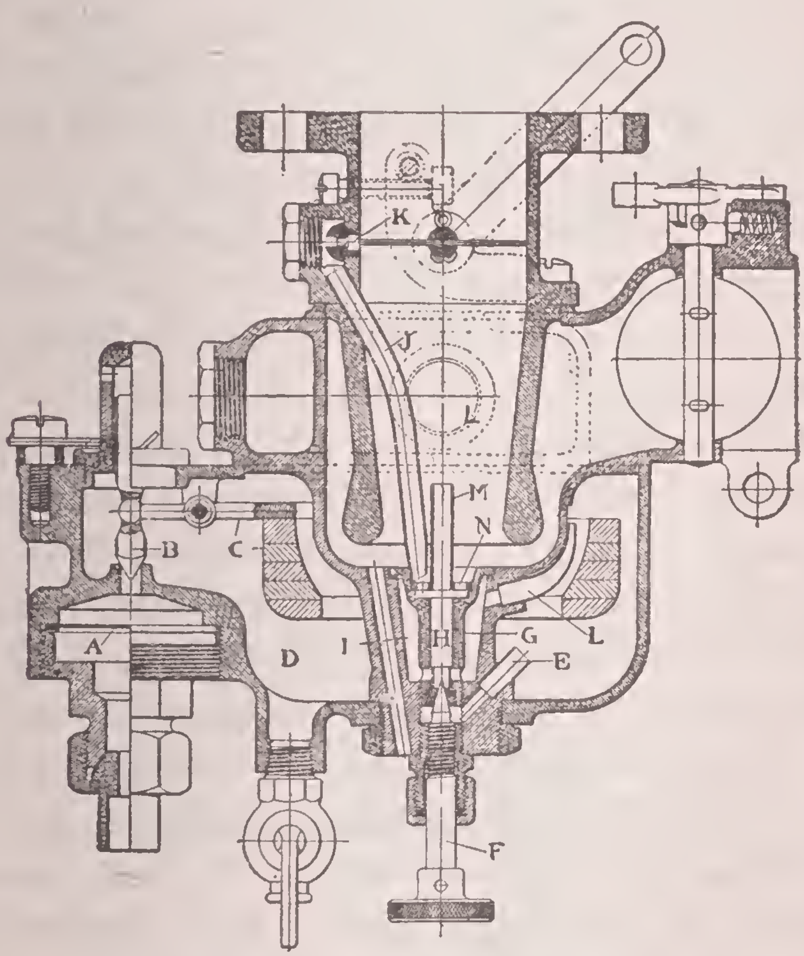


Fig. 65
Holly Carburetor, Model "H"

Cranking the engine, with the throttle kept nearly closed, causes a very energetic flow of air through the tube J and its calibrated throttling plug K, but the lower end of this tube is submerged in fuel, with the engine at rest. Therefore, the act of cranking automatically primes the motor. With the motor turning over, under its own power, flow through the tube J takes place at very high velocity, thus causing the fuel entering the tube with the air to be thoroughly atomized upon its exit from the small opening at the throttle edge. This tube is called the "low speed tube" because, for starting and idle running, all of the fuel and most of the air in the fuel mixture are taken through it.

As the throttle opening is increased beyond that needed by idling of the motor, a considerable volume of air is caused to move through the passage bounded by the conical walls L of the so-called strangling tube. In its passage into the strangling tube, the air is made to assume an annular, converging-stream form, so that the point in its flow at which it attains its highest velocity is in the immediate neighborhood of the upper end of the "standpipe" M, set on to the body of the nozzle piece G. The velocity of air flow being highest at the upper, or outlet, end of the standpipe, the pressure in the air stream is lowest at the same point. For this reason there is a pressure difference between the top and bottom openings of the pipe M, thus causing air to flow through it from bottom to top, the air passing downward through the series of openings N in the standpipe supporting-bridge and then up through the standpipe.

With a very small throttle opening, the action through the standpipe keeps the nozzle thoroughly cleaned out, the fuel passing directly from the needle opening into the entrance of the standpipe. To secure the utmost atomization of the fuel, the passage through the standpipe is given aspirator form, which further increases the velocity of the flow through it, and insures the greatest possible mixture of the fuel with the air. A further point is that the atomized discharge of the standpipe enters the air stream at a point at which the latter attains its highest velocity and lowest pressure.

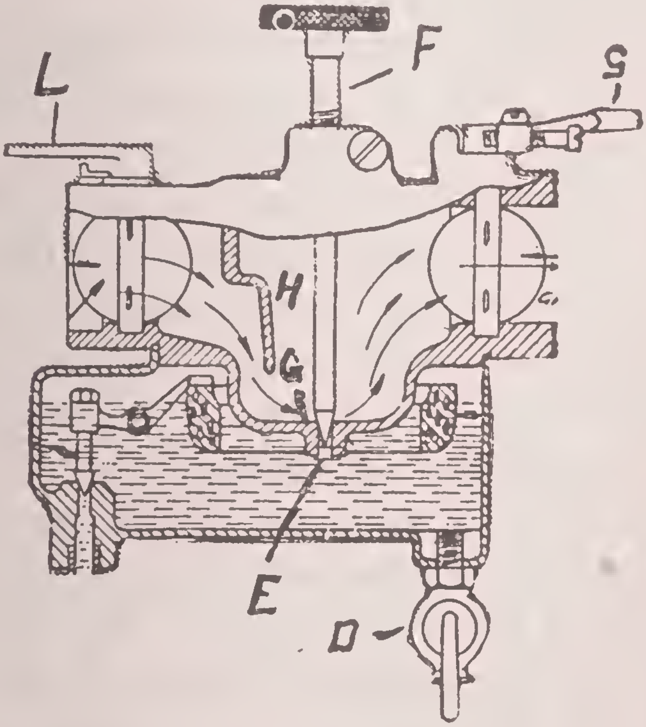


Fig. 66
Holly Carburetor, Model "G"

There is but one adjustment, the needle valve I. The effect of a change in its setting is manifest equally over the whole range of the motor.

Holly Carburetor, Model G. This design is especially for Ford cars. Its method of operation is identical with that of the Model H, its chief differences as compared with the other model being structural ones, giving a horizontal instead of a vertical outlet, a needle valve controlled from above, and a general condensation of the design to secure compactness.

Fuel enters the carburetor, shown in Fig. 66, by way of a float mechanism in which a hinged ring float, in rising with the fuel, raises the float valve into contact with its seat. The seat is a removable piece and the float valve is provided with a tip of hard material.

From the float chamber the gasoline passes through the ports E to the nozzle orifice in which is located the pointed end of the needle F. It is noted that the ports E are well above the bottom of the float chamber, so that, even should water or other foreign matter enter the float chamber it would have to be present in a considerable quantity before it could interfere with the carburetor operation.

A drain valve D is provided for the purpose of drawing off whatever sediment, or water, may accumulate in the float chamber. The float level is so set that the gasoline rises past the needle valve F and fills the cup G to submerge the lower end of the small tube H. Drilled passages in the casting communicate with the upper end of this tube with an outlet at the edge of the throttle disk. The tube and passage give the starting and idling actions, as described in connection with the Model H.

The strangling tube I gives the entering air stream an annular converging form, in which the lowest pressure and highest velocity occur immediately above the cup G; thus it is seen that the fuel issuing past the needle valve F is immediately picked up by the main air stream at the point of the latter's highest velocity.

The lever L operates the throttle in the mixture outlet, and a larger disk with its lever S is a spring-returned strangler valve in the air intake, for facilitating starting in extremely cold weather.

Kingston Carburetor. The Kingston carburetor, Fig. 67, uses a ball type of auxiliary

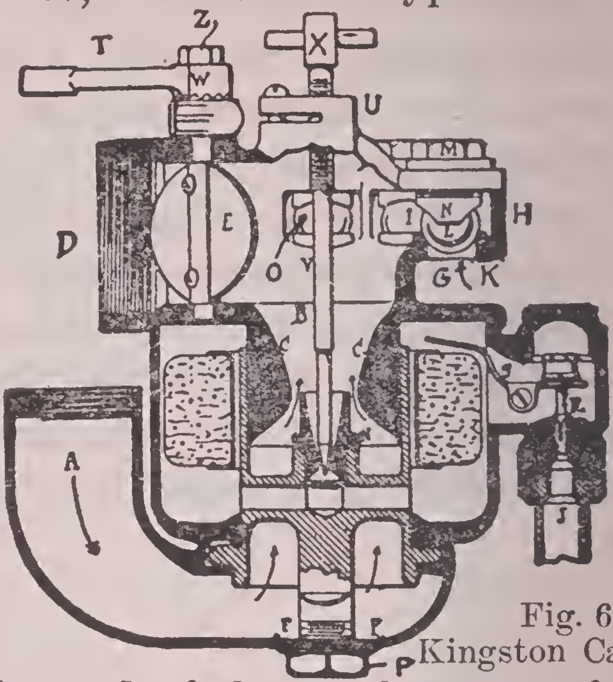


Fig. 67
Kingston Carburetor

air valve instead of the employment of spring control dashpot, diaphragm or auxiliary air valve. The main air intake A communicates with the vertical mixing chamber B, in which the sides C are beveled outward, giving a center tube effect, so that the air current converges above the nozzle N, as indicated by the arrows. D marks the exit to the motor controlled by the butterfly throttle E. Auxiliary air enters through five circular openings G, arranged in a semi-circle in the floor of an extension H of the mixing chamber. Each of these five openings consists of a bushing K threaded into the opening in the extension H, and having its top beveled to receive a five-eighths inch bell metal bronze ball L, which is retained in position by a threaded bushing M, fitting in the top of the extension H. It has a pair of downward projecting hooks N for preventing the ball getting out of position, but not interfering with the ball rising vertically when forced to do so by the pull of the motor, at which time additional air is admitted. Two others of the five auxiliary entrances are shown at I and O, all of the five containing balls of the same size and weight. The air entering through the openings guarded by these balls has an unrestricted passage into the mixing chamber and thence to the motor. Any ball is easily moved by unthreading the cap M, after which the ball can be lifted out.

The gasoline enters the carburetor from the gasoline tank by way of the connection J, which is guarded by the needle valve R, operated through the lever S, pivoted in the side of the casting and with its long arm bearing on the top of the cork float. The float is fitted with a metal bushing. Complete control of the nozzle N is through the needle valve V, which, at the top of the carbureter, has a T-piece X, by which it can be raised or lowered, thereby regulating the flow of gasoline. A feature of the throttle connection T is the serrated lower face of its hub W, so that by loosening a lock nut Z, the handle T may be turned in any direction most convenient. The air intake A consists of an L-shaped piece secured to the carbureter casting by a nut P, and in the base of this is a circle of openings F where currents of air can enter, the object of these openings being that by priming the carburetor, and overflowing the open mouth of nozzle N the gasoline falls to the vicinity of the holes F, and the air entering through these openings will facilitate the breaking up of the gasoline, and thereby assist the starting of the motor.

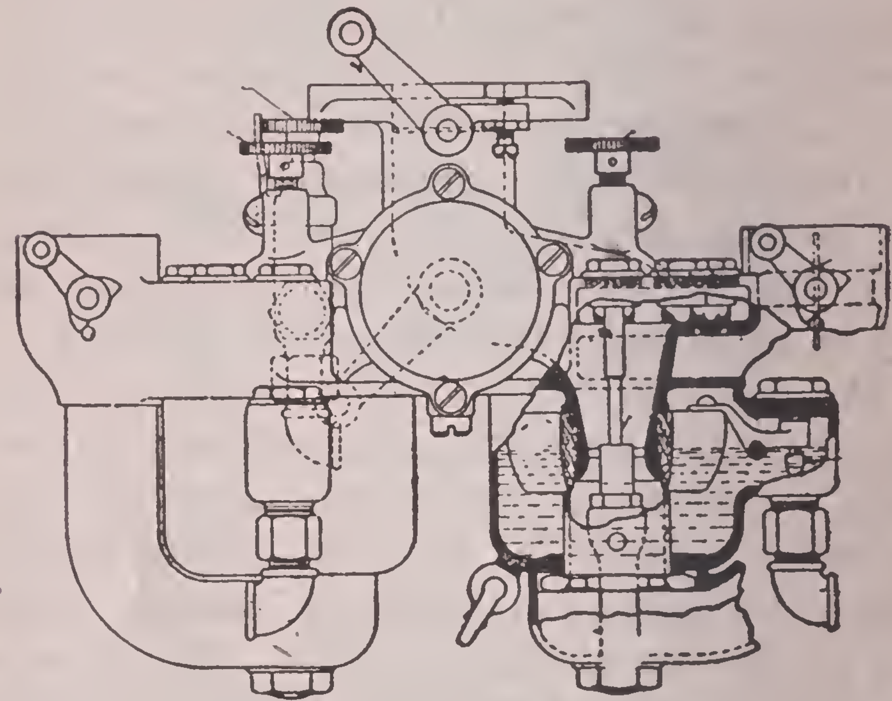


Fig. 68
Double Bowl Carburetor

RAYFIELD CARBURETOR. The Rayfield carburetor has no direct adjustment for the nozzle opening such as would be provided by a screw needle valve, but to take the place of such an adjustment a type of lever mechanism is used that increases or decreases the gasoline supply according to the degree of throttle opening, and also provides means for adjusting the fuel flow for high or low speeds independently of each other. Adjustment is provided through two screws with milled heads, one of these serving to fix the position of the nozzle adjustment at low engine speeds or with a nearly closed throttle and the other one operating only when the throttle is more than half way open. The construction of this instrument is clearly shown in Figs. 69, 70 and 71, and the method of adjustment is described on the following pages.

Model D, Fig. 69—Adjusting low speeds:—Close needle valve by turning low speed screw to the left until arm U slightly leaves contact with the cam. Then turn to the right one and one-half turns, open throttle one-quarter, prime carburetor and start motor. Close throttle until motor runs slowly without stopping. Turn low speed screw to the left one notch at a time until motor idles smoothly. If motor does not throttle low enough turn screw in stop arm to the left with a screw driver. Carburetor is now adjusted for low speed.

Adjusting high speed:—Now open the throttle slowly until wide open. Should motor backfire turn high speed adjusting screw to the right, a half turn at a time, until motor runs without a miss. Should motor not backfire turn high speed adjusting screw to the left until it does, then to the right until motor runs smoothly and powerfully.

Do not use low speed adjustment to get a correct mixture at high or intermediate speeds.

Should motor backfire or mixture be too light at intermediate speeds (throttle about ¼ open)

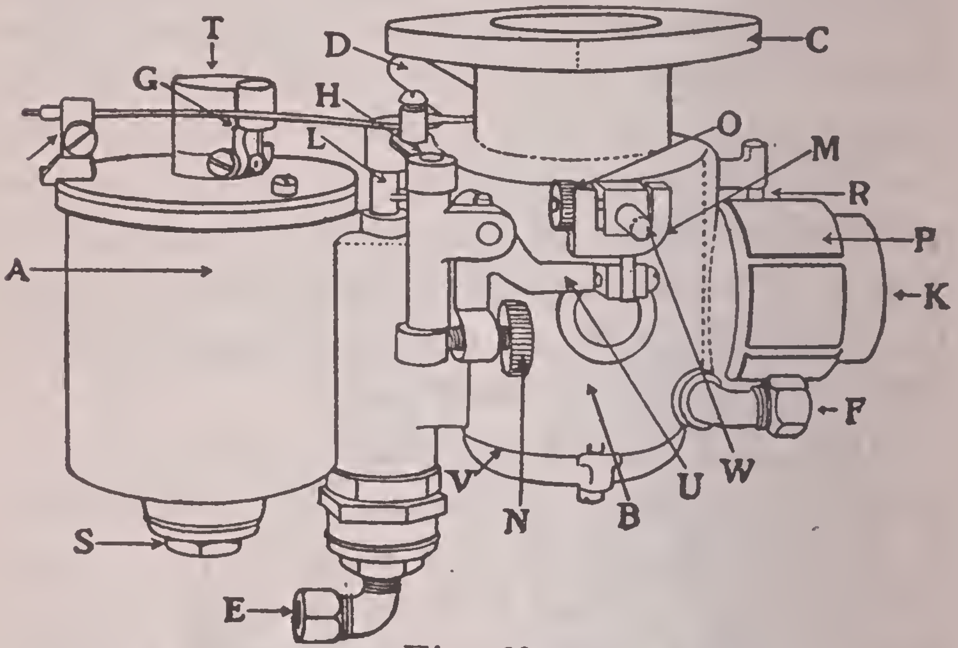


Fig. 69

Rayfield Carburetor, Model "D". A, Float Chamber. B, Mixing Chamber. C, Flange. D, Throttle Lever. E, Gasoline Intake. H, Gas Arm. J, Dash Adjustment. K, Air Valve. L, Needle Valve. M, Regulating Cam. P, Air Adjustment. R, Air Lock. S, Drain Plug. T, Priming Cap. U, Needle Arm. F, Water Connection. G, Priming Lever. N, Low Speed Adjustment. O, High Speed Adjustment. V, Primary Air Intake. W, Cam Shaft.

turn air valve adjustment P to the right a turn or two, thus increasing the spring tension and decreasing quantity of air slightly.

Remember that it is best to use all the air that the motor will handle without being sluggish.

Do not change the float level. It is correctly set at the factory. Always prime carburetor well before starting motor. Pull steadily on primer string. Don't jerk.

Do not cut down the air supply, unless the gasoline adjustments fail to give you a powerful and fast mixture.

If motor does not get the correct mixture at intermediate speed or high speed, do not try to remedy it through a low speed adjustment. Remember, the low speed adjustment is to be adjusted only when the motor is running idle.

In starting motor, do not open throttle more than one-quarter. The motor will start more readily with the throttle slightly opened and it is harmful as well as useless to race the motor in starting.

Before cranking motor pull dash button up. After motor has "warmed up" push dash button down to Running Position.

In stopping motor pull up dash button, open throttle about ¼ inch, and switch off ignition, thus leaving a sufficient volume of rich mixture in the cylinders, which assures easy starting when the motor is again used.

Models G and L, Figs. 70 and 71, have no air valve adjustment and only two gasoline adjustments.

Always adjust carburetor with dash control down. Low speed adjustment must be completed before adjusting "high."

Adjusting low speed:—With throttle closed, and dash control down, close nozzle needle by turning Low Speed adjustment to the left until

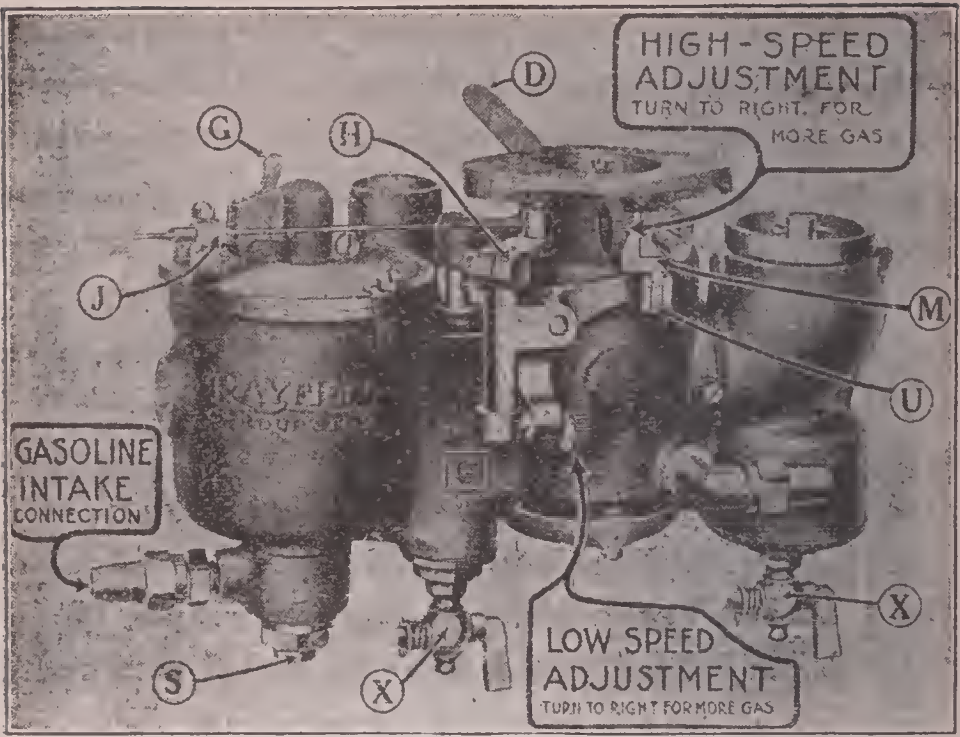


Fig. 70
Rayfield Carburetor, Model "G". D, Throttle Arm. G, Priming Lever. H, Gasoline Arm. M, Regulating Cam. S, Drain Cock. U, Needle Valve Arm. X, Drain Cock. J, Gasoline Control Lock.

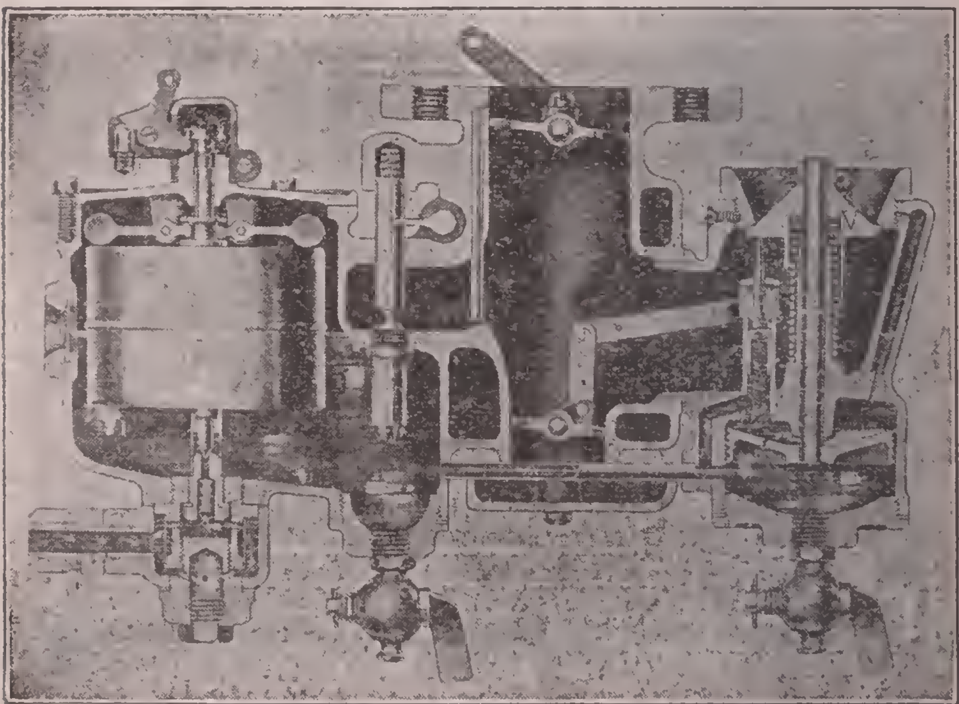


Fig. 71—Rayfield Carburetor, Model "G", Internal Construction

Block U slightly leaves contact with the cam M. Then turn to the right about three complete turns. Open throttle not more than one-quarter. Prime carburetor by pulling steadily a few seconds on priming lever G. Start motor and allow it to run until warmed up. Then, with retarded spark, close throttle until motor runs slowly without stopping. Now, with motor thoroughly warm, make final low speed adjustment by turning low speed screw to left until motor slows down, and then turn to the right a notch at a time until motor idles smoothly.

If motor does not throttle low enough, turn stop arm screw A to the left until it runs at the lowest number of revolutions desired.

Adjusting High Speed:—Advance spark about one-quarter. Open throttle rather quickly. Should motor backfire it indicates a lean mixture. Correct this by turning the high speed adjusting screw to the right about one notch at a time, until the throttle can be opened quickly without a backfiring.

If "loading" (choking) is experienced when running under heavy load with throttle wide open, it indicates too rich a mixture. This can be overcome by turning high speed adjustment to the left.

Adjustment made for high speed will in no way affect low speed. Low speed adjustment must not be used to get a correct mixture at high speed. Both adjustments are positively locked.

Starting:—Before starting motor when cold observe the following. Open throttle not more than one-quarter. Enrich the mixture by pulling up dash control. Prime carburetor by pulling on priming lever G for a few seconds.

When stopping motor, pull up dash control. Open throttle about one-quarter and switch off ignition. This leaves a rich mixture in the motor, which insures easy starting.

Raising dash control enriches the mixture by lifting the nozzle needle. Control button should be down for running, except when a richer mixture is required.

Pull button up full distance for starting.

Adjustment of carburetor should always be made with dash control down and motor warm.

SCHEBLER CARBURETORS. This make of instrument has been built in a number of different models, the first one of which to be used in large numbers was the Model D. All of the important types of Schebler carburetors now in use are described and instructions given for their adjustments on the following pages.

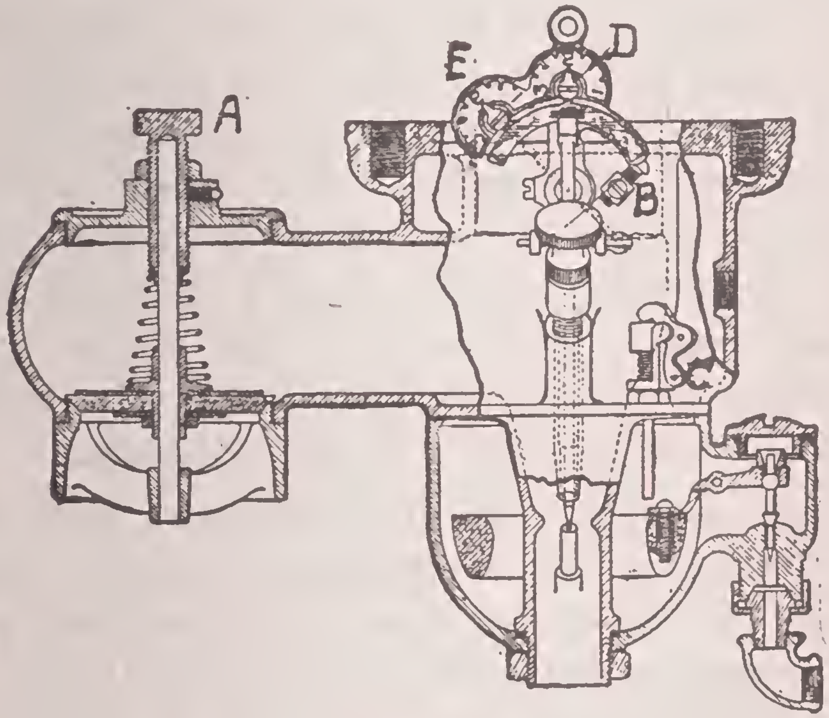


Fig. 72
Schebler Carburetor, Model "L". A, Auxiliary Air Valve. B, Gasoline Needle Valve. C, Priming Lever. D, Intermediate Speed Cam. E, High Speed Cam.

The Model L carburetor, Fig. 72, is a type of lift needle carburetor and is so designed that the amount of fuel entering the motor is automatically controlled by means of a raised needle working automatically with the throttle. The adjustment or control of gasoline in this instrument can be adjusted for low, intermediate or high speed, each adjustment being independent and not affecting either of the other adjustments.

In adjusting the carburetor, first make adjustment on the auxiliary air valve A so that it seats firmly but lightly; then close the needle valve by turning the adjustment screw B to the right until it stops. Do not use any pressure on this adjustment screw after it meets with resistance. Then turn it to the left from four to five complete turns and prime or flush the carburetor by pulling up the priming lever C and holding it up for about five seconds. Next, open the throttle about one-third, and start the motor; then close the throttle slightly, retard the spark and adjust throttle lever screw F and needle valve adjusting screw B so that the motor runs at the desired speed and fires on all cylinders.

After getting a good adjustment with the motor running idle, do not touch the needle valve adjustment again, but make all intermediate and high speed adjustments on the dials D and E. Adjust pointer on the first dial D from the number 1 towards 3, about half way between. Advance the spark and open throttle so that the roller on the track running below the dials is in line with the first dial. If the motor backfires with the throttle in this position, and the spark advanced, turn the indicator a little more toward number 3; or if the mixture is too rich turn the indicator back or toward number 1, until motor is running properly with the throttle in this position, or at intermediate speed. Now, open the throttle wide and make adjustment on the dial E for high speed in the same manner as for intermediate speed on dial D.

In the majority of cases in adjusting this carburetor the tendency is to give too rich a mixture. In adjusting the carburetor both at low, intermediate and high speeds, cut down the gasoline until the motor begins to backfire, and then increase the supply of fuel, a little at a time, until the motor hits evenly on all the cylinders. Do not increase the supply of gasoline by turning the needle valve adjusting screw more than a notch at a time in the low-speed adjustment, and do not turn it any after the motor hits regularly on all cylinders. In making the adjustments on the intermediate and high speed dials, do not turn the pointers more than one-half way at a time between the graduated divisions or marks shown on the dials.

The Model R Schebler carburetor, Fig. 73, is a single jet raised needle type of carburetor, automatic in action. The air valve controls the lift of the needle and automatically proportions the amount of gasoline and air at all speeds.

The Model R carburetor is designed with an adjustment for low speed; as the speed of the motor increases the air valve opens, raising the gasoline needle, thus automatically increasing the amount of fuel. The carburetor has but two adjustments—the low speed needle adjustment, which is made by turning the air valve cap and an adjustment on the air valve spring for changing its tension.

This carburetor has an eccentric which acts on the needle valve, intended to be operated either from the steering column or from the dash, and insures easy starting, as by raising the needle from the seat an extremely rich mixture is furnished for starting, and for heating up the motor in cold weather. A choker in the air bend is also furnished.

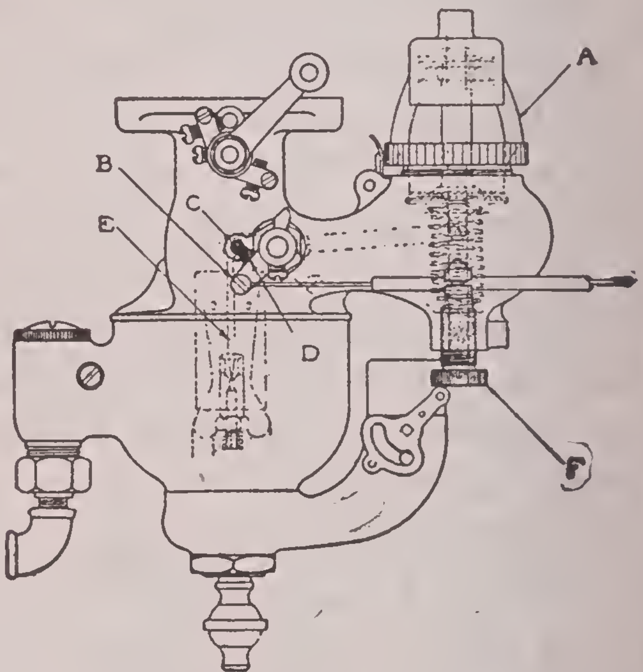


Fig. 73

Schebler Carburetor, Model "R". A, Low Speed Adjustment. B, Starting Cam Lever. C, Needle Valve Connection. D, Starting Cam. E, Needle Valve. F, High Speed Adjustment.

When carburetor is installed see that lever B is attached to steering column control or dash control, so that when boss D of lever B is against stop C the lever on steering column control or dash control will register "Lean" or "Air."

This is the proper running position for lever B.

To adjust carburetor turn air valve cap A clockwise or to the right until it stops, then turn to the left or anti-clockwise one complete turn.

To start engine open throttle about one-eighth or one-quarter way. When motor is started let it run till engine is warmed, then turn air valve cap A to left or anti-clockwise until engine hits perfectly. Advance spark three-quarters of the way on quadrant, if engine backfires on quick acceleration turn adjusting screw F up (which increases tension on air valve spring) until acceleration is satisfactory.

Turning air valve cup A to right or clockwise lifts needle E out of nozzle and enriches mixture; turning to left or anti-clockwise lowers the needle into nozzle and makes mixture lean.

When motor is cold or car has been standing, move steering column or dash control lever towards "Gas" or "Rich" which lifts needle E out of gasoline nozzle and makes rich mixture for starting. As motor warms up, move control lever gradually back towards "Air" or "Lean" to obtain best running conditions until motor has reached normal temperature. When this temperature is reached control lever should be at "Air" or "Lean."

For best economy and power, the slow speed adjustment should be made as lean as possible.

Stromberg Carburetors are made with a nozzle, the opening in which is not adjustable. This nozzle is a separate part of the carburetor and is screwed into place from below. In order to adjust the gasoline flow it is necessary to remove one nozzle and replace it with one having a larger or smaller opening. The nozzles are marked according to drill gauge sizes and the opening becomes larger as the number becomes lower, that is to say, a number 59 is larger than a number 60 and a number 58 is larger than a number 59.

If, after making low speed adjustment it is found that the air valve remains off its seat or that indications of a rich mixture are still present, the nozzle is too large. If the high speed adjustment has to be screwed very tight it indicates that the nozzle is too small. In changing nozzles do so one size at a time, that is, do not drop from number 60 to a number 58, but use a 59 first.

Instructions for type A. Type A, Fig. 74, is a water jacketed carburetor. It has its spray nozzle PN mounted in the center of the carburetor with its point 3-16 of an inch above the normal gasoline level and surrounded by a modified venturi tube. This nozzle is proportionate in size to the carburetor and never needs attention or adjustment.

After the carburetor is installed and the gasoline turned on, note the level of the gasoline in the float chamber. It should be about one inch from the lower edge of the glass. This level is adjusted at the factory and should be right. In case it is obviously wrong, remove the dust cap D and turn the adjusting screw S until the proper level is obtained. If the gasoline is too high, screw the nut down. If gasoline is too low, screw the nut up. Don't change unless absolutely necessary.

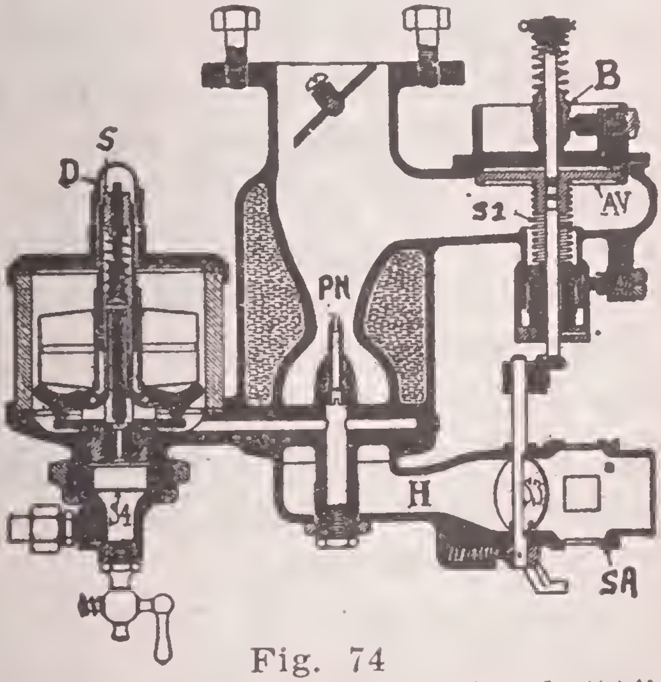


Fig. 74
Stromberg Carburetor, Model "A"

To start the motor close the valve S3 in the hot air horn H. The motor should then start on the second or third turn of the crank. If not, open the valve and it ought to start on the next turn. Great care should be taken to see that this valve is instantly opened as the motor starts, and is kept open.

Season adjustments. Open and close shutter SA—open in summer and closed in winter.

Low speed adjustment. Turn up the adjusting nut A until the spring S1, which is the low speed spring, seats the valve lightly. See that the high speed spring above B is free and does not come in contact with the nut on top of the auxiliary air valve stem. Start the motor and turn nut A up or down until motor idles properly. This is the low speed adjustment.

High speed adjustment. Advance the spark and open the throttle. If the motor backfires through the carburetor, turn high speed adjusting nut B up until backfiring ceases. If, with this adjustment and running at low speeds, motor gallops, or the carburetor loads up, the mixture is too rich. The nut B should then be turned down until galloping or loading ceases. This is the high speed adjustment. The spring above nut B should always have at least 1-32 inch clearance between it and the nut at the top when the motor is at rest.

Instructions for type B. Type B, Fig. 75, is a concentric type carburetor. It has its spray nozzle PN mounted in the center of the carburetor, and in the center of the float chamber, with its point 3-16 of an inch above the normal gasoline level and surrounded by a modified venturi tube.

The level of the gasoline in the float chamber should be about 15-16 of an inch from the lower edge of the glass marked X. This level is adjusted at the factory and should be right. In case it is wrong, remove the dust cap D and turn the adjusting screw S until the proper level is obtained. If the gasoline is too high screw the nut down. If the gasoline is too low screw the nut up. Don't change unless absolutely necessary.

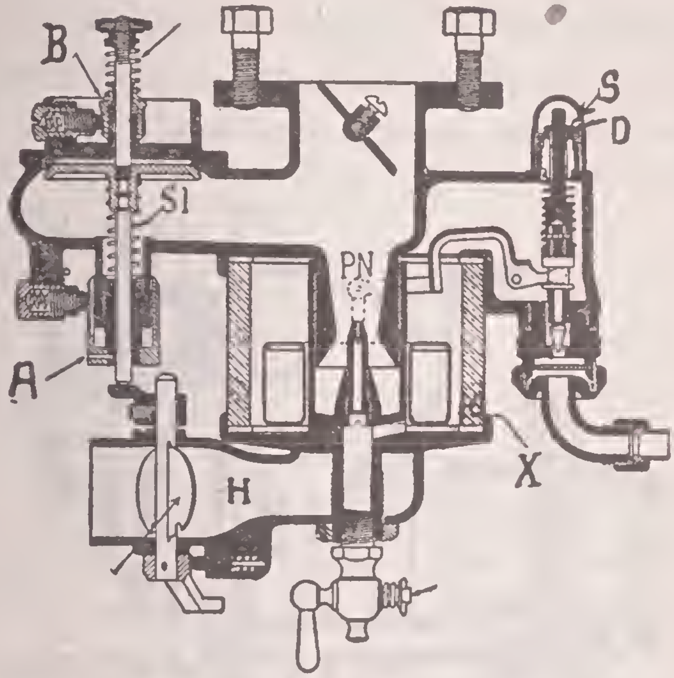


Fig. 75

Stromberg Carburetor, Model "B"

Low speed adjustment. Turn up the adjusting nut A until the spring S1, which is the low speed spring, seats the valve lightly. See that the high speed spring above B is free and does not come into contact with the nut on top of the auxiliary air valve stem. Start the motor and turn nut A up or down until motor idles properly. This is the low speed adjustment.

High speed adjustment. Advance the spark and open the throttle. If motor backfires through the carburetor, turn high speed adjusting nut B up until backfiring ceases. If, with this adjustment and running at low speeds motor gallops, or the carburetor loads up, the mixture is too rich. The nut B should then be turned down until galloping or loading up ceases. This is high speed adjustment. The spring above nut B should always have at least 1-32 inch clearance between it and the nut at the top when the motor is at rest.

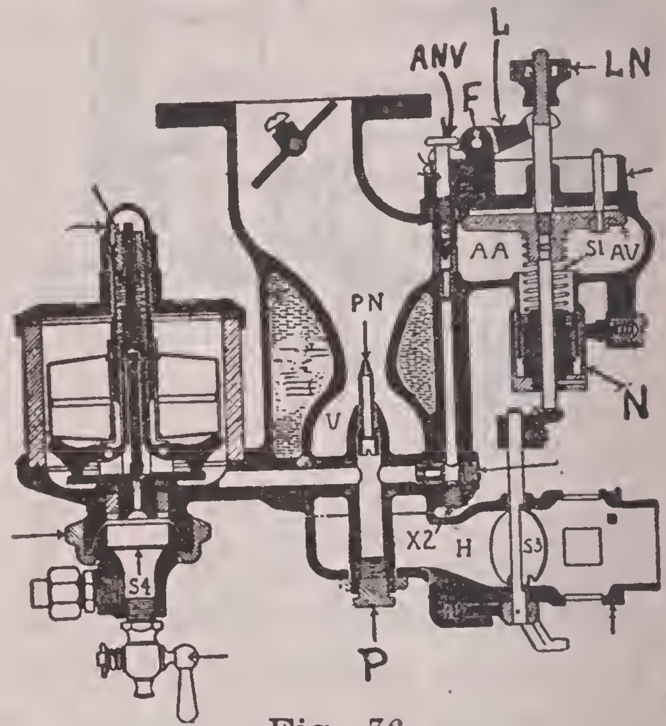


Fig. 76
Stromberg Carburetor, Model "C"

Instructions for type C. Type C, Fig. 76, is equipped with two separate gasoline spray nozzles. The first or primary nozzle PN is mounted in the venturi tube V; this nozzle supplying sufficient gasoline for all speeds up to twenty or twenty-five miles per hour. The second or auxiliary nozzle is mounted just beneath the secondary gasoline needle valve ANV in the auxiliary air passage AA, and is opened by the lever L operating over a fulcrum F by the opening of the auxiliary air valve AV.

Turn up the lower adjusting nut N, located underneath the auxiliary air valve, so that the valve is brought up to seat, then give two full turns to the right as a starting adjustment. This valve should be seated on extreme idle. The spring S1 is the low speed spring and does the work up to the opening of the auxiliary needle.

Start the motor and turn low speed nut N up or down until the motor idles properly, then advance the spark, open the throttle, and if the motor backfires turn nut LN down until it ceases. If mixture is too rich, turn it up. Be sure that nut LN and lever L have some clearance on low speed.

The proper gasoline level is about 1 inch from the lower edge of the glass. If more than ⅛ inch either way remove the dust cap and adjust by screws.

High speed adjustment. The high speed is regulated by the lock nut LN on top of the auxiliary air valve. As it is raised or lowered it determines the point at which the auxiliary needle valve ANV will be brought into play. To lock nut LN should be about 3-32 of an inch above the lever L for normal adjustment, but this distance can be increased or decreased to suit the motor.

To find primary nozzle size. If the mixture is too rich on low speed after adjustments are made according to instructions, take out the plug P and remove the nozzle PN with a screwdriver. Insert smaller nozzle (59 is smaller than 58). If the mixture is too lean on low speed a larger nozzle should be inserted. If the engine misses on low speed it may be caused by an air leak, and all the joints between the carburetor and the motor should be examined before a large nozzle is inserted.

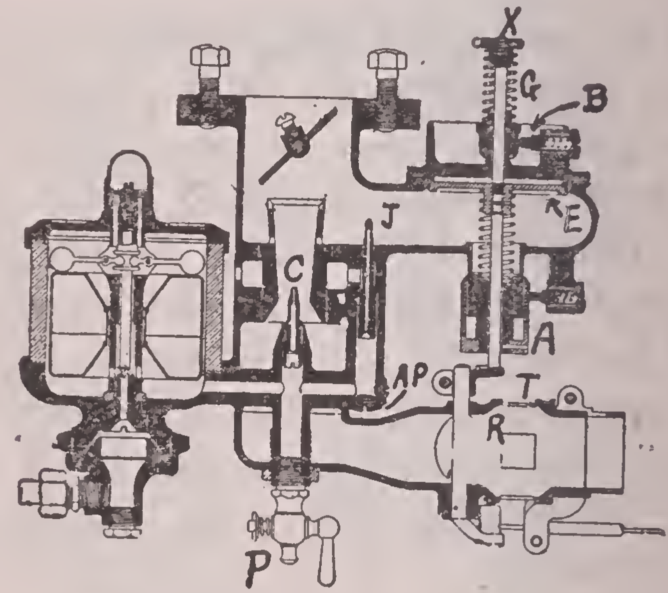


Fig. 77
Stromberg Carburetor, Model "G"

Instructions for type G. Type G, Fig. 77, is a non-water-jacketed model furnished in either single or double jet according to motor requirements.

Air adjustments. There are only two adjustments that ever need attention, A, the low speed nut, and B, the high speed nut.

With the motor at rest, set the high speed nut B so there is at least 1-16 of an inch clearance between the spring G and the nut X above it. This is imperative.

Set the low speed nut A so the air valve E is seated lightly. Do not adjust carburetor until motor is thoroughly warmed up. When motor is warm and with spark retarded adjust nut A up or down until motor runs smoothly at low speed. To determine proper adjustment open the air valve with finger by depressing X slightly. If, when so doing, motor speeds up noticeably it indicates too rich a mixture and A should be turned down notch by notch. If, on the other hand, motor dies suddenly when slightly opening the air valve it indicates too lean a mixture and A should be turned up until this is overcome.

Once properly set for idling do not change this adjustment when making the high speed adjustment.

Advance the spark at the normal position and open the throttle gradually. If motor back-fires through the carburetor it is positive indication of too lean a mixture and nut B should be turned up notch by notch until this is overcome.

If mixture is too rich, as indicated by loading of the motor and heavy black smoke from the exhaust, turn B down until motor operates properly. A further test for the correct mixture at high speed can be made by depressing the air valve when the motor is running at this speed. If when so doing motor speeds up it indicates too rich a mixture.

Turning either adjusting nut up means a

richer mixture or more gas. Down means a leaner mixture or more air. To get highest efficiency from this carburetor, hot air equipment should be used.

Double jet type. If, after following the instructions given below, and with the motor running idle at low speed, the air valve E remains tightly seated, it indicates too small a primary nozzle C, and a larger one should be substituted. If with the proper adjustment, and after stopping the engine, the air valve hangs off its seat the primary nozzle is too large and a smaller one should be used. To change the primary nozzle remove the petcock, insert a narrow screwdriver and unscrew the nozzle.

If the mixture at low speed is correct, but in order to get the proper high speed adjustment it is necessary to turn the nut B up so far that the spring G is in contact with X above it, after the engine has been stopped, it indicates that the auxiliary nozzle J is too small and a larger one should be used. If it is necessary, in order to get the proper high speed adjustment, to turn the nut B down so that there is more than 1/8 inch clearance between G and X when the engine is idle, it indicates too large an auxiliary nozzle and a smaller one should be used.

Instructions for types H and HA. There are only two adjustments on this carburetor, Fig. 78. A, the low speed, and B for high speed. A is a needle valve, seating in an open nozzle, the opening of which is usually two sizes larger than is ordinarily necessary, and which permits an increase in gasoline flow to that extent or allows a complete closing. The high speed adjustment controls the flow of gasoline for high speeds by regulating the time at which the secondary needle valve begins to open.

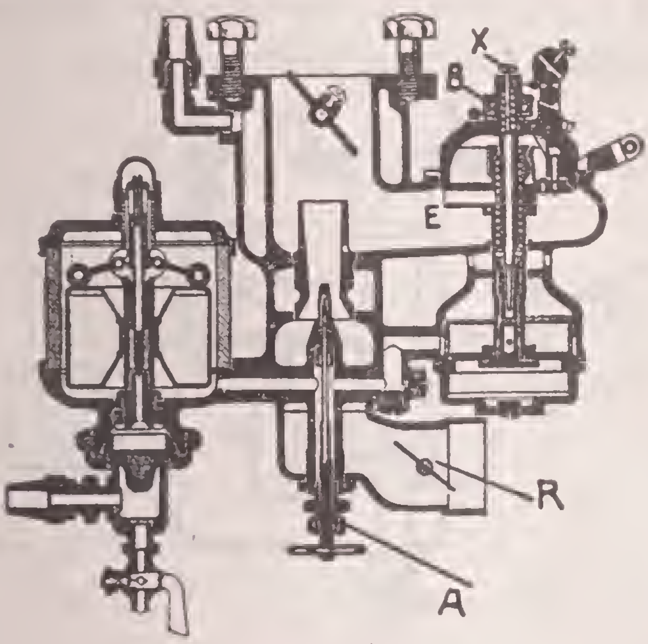


Fig. 78

Stromberg Carburetor, Models "H" and "HA"

To adjust, set the high speed nut B so that there is at least 1-32 of an inch clearance between it and the needle valve cap above it at X when the air valve E is on its seat. The needle valve does not begin to open until B comes into contact with X. Before starting the engine be sure that the rocker arm of the dash adjustment on the carburetor is not in contact with the collar above it at Z when the steering post button is all the way down.

To start the engine, pull the steering post control to its highest position, thus producing a rich mixture. In cold weather it may also be necessary to close the air supply in the hot air horn by means of a rod connected to R. This should be again opened as soon as the engine starts. As the engine warms up, gradually lower the steering post control and make sure that it is at its lowest position before commencing to adjust the carburetor.

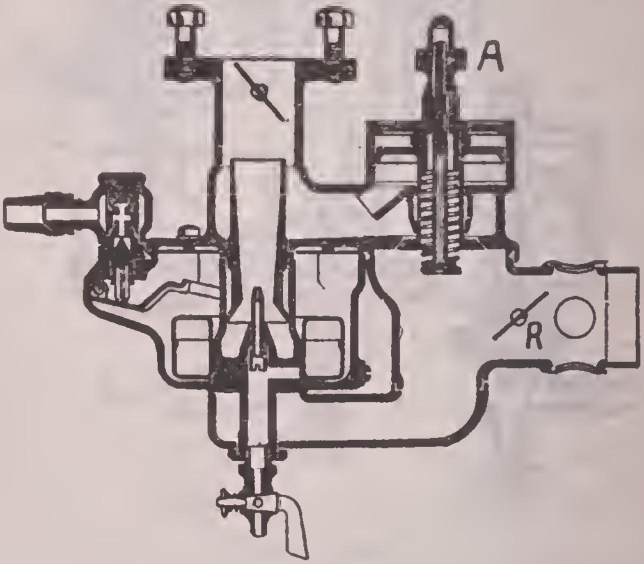


Fig. 79
Stromberg Carburetor, Model "K"

The mixture at low speed is controlled by the needle valve A. If too rich is indicated, by the engine "rolling" or "loading," turn A up or anti-clockwise. If the mixture is not rich enough, turn A down or clockwise. To adjust high speed, advance the spark and open the throttle. If the mixture is not rich enough at high speeds, turn B up or anti-clockwise, and if the mixture is too rich turn B down or clockwise.

Instructions for types K and KO. The nut

A is the only adjustment on this carburetor, Fig. 79. The stem of this nut supports the lower end of a spring that controls the air valve. This air valve opens downward into the air chamber. Turning the nut A clockwise or down tightens this spring, admitting less air and producing a richer mixture. Turning A in the opposite direction or anti-clockwise produces a leaner mixture.

Before starting the engine turn A anti-clockwise until a point is reached where, when lifting or pulling up on A, a decided click is heard. This is the air valve coming in contact with its seat. Then turn A clockwise or down until the click is no longer obtained. This turning should be a notch at a time, and when the click can not be heard, turn two more notches in the same direction. To start the engine, raise the steering post control to its highest position. Gradually lower the control as the engine warms up, and make sure that this control is at its lowest position before starting to adjust the carburetor. With the engine warm, turn A up or down, notch by notch, until the engine idles properly. It should not be necessary to change the initial setting more than a few notches.

The high speed mixture can only be affected by changing the nozzle. If the high speed mixture is too thin, so that slightly closing the dash throttle valve R causes an increase of engine speed, a larger nozzle should be used. If the high speed mixture is too rich use a smaller nozzle. The nozzle size furnished is based on 18 inches of hot air tubing. If this tubing is more than 24 inches long, one size smaller nozzle can probably be used, while if the tubing is less than 10 inches long one size larger may be required.

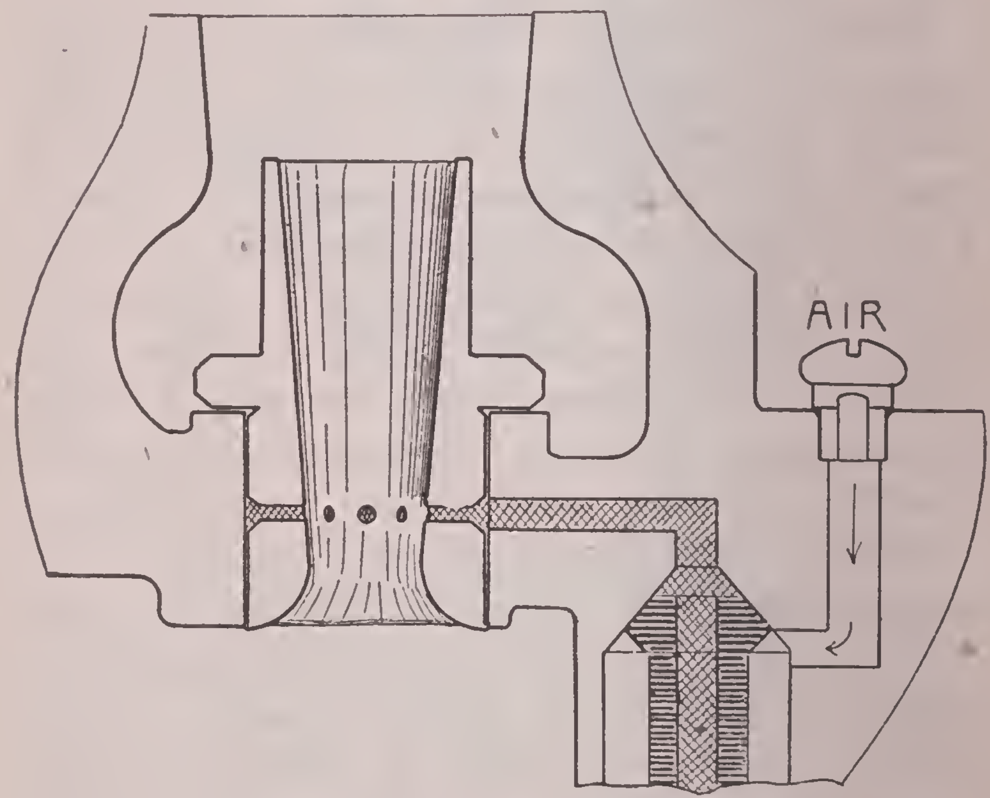


Fig. 80
Stromberg Air Bled Jet

STROMBERG PLAIN TUBE CARBURETORS. These instruments differ from the older models in that they are of the plain tube type having all air passages fixed in size and without valves, while the gasoline is measured by the air flow itself. The mixture proportion is maintained constant by a peculiar form of jet shown in Figure 80, in which a small amount of air is mixed with the gasoline before the fuel reaches the main jets.

For the Model L carburetor, shown in Figure 81, also for the corresponding side outlet type, Model LB, there are three adjustments, high speed, idling and starting. The high speed is

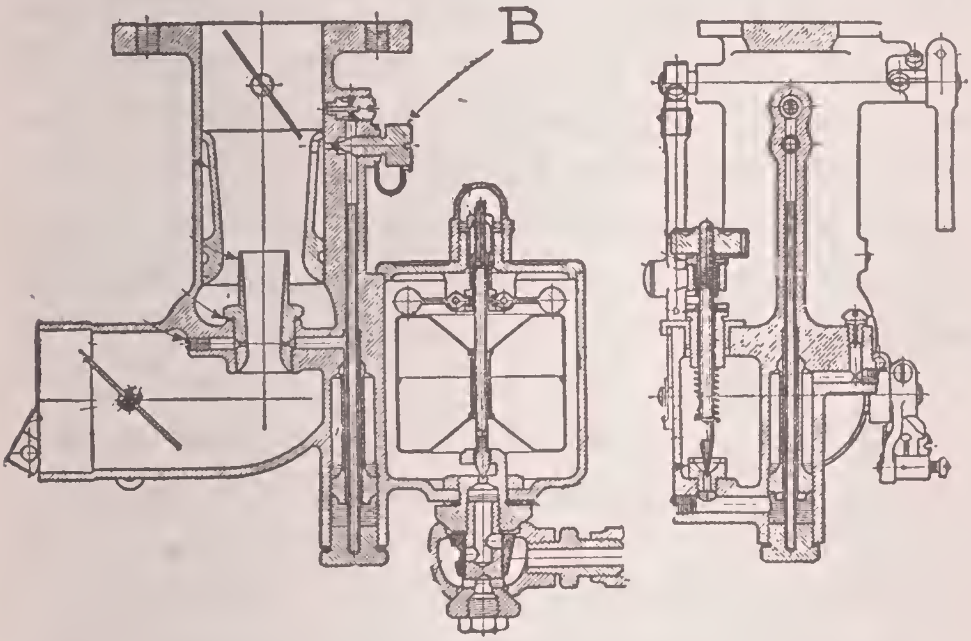


Fig. 81
Stromberg Model L Carbureter

controlled by the knurled nut marked "High Speed" which locates the position of the needle past whose point is taken all the gasoline at all speeds. Turning this nut to the right, clockwise, raises the needle and gives a richer mixture; while turning to the left gives a leaner mixture.

To make an adjustment put the starting lever L in the fifth notch, farthest from the float chamber and turn the high speed nut to the left until the needle reaches its seat as shown by the nut moving when the throttle is opened and closed. When the needle is on its seat it can be felt to stick slightly when the nut is lifted with the fingers. Find the point of adjustment where this nut just begins to move with the throttle opening, then turn 24 notches to the right. Now move the starting lever back to the O notch, toward the float chamber, which will give a rich adjustment. After starting and warming the engine the mixture may be made leaner by turning the high speed nut to the left until a point is found where the engine responds best to quick opening of the throttle and shows the best power.

The low speed or idling adjustment is controlled by the adjusting screw B. The gasoline for idling is taken in above the throttle and is regulated by dilution with air. Screwing nut B in, or clockwise, gives a richer mixture while turning it outward gives more air. The best adjustment is usually from one-half to three turns outward from the seating position. This is only an idling adjustment and does not affect the mixture above 8 miles per hour. When the engine is idling properly there should be a steady hiss in the carburetor. If there is a weak cylinder or a leak in the manifold, or if the idle adjustment is very much too rich, the hissing will be unsteady.

The starting device, called the "economizer," operates to make a leaner mixture through lowering the high speed needle at throttle positions corresponding to speeds from five to forty miles per hour. The amount of needle drop and consequent leanness is regulated by the position of the pointer.

After making the high speed adjustment for best power with the pointer in the O notch, place

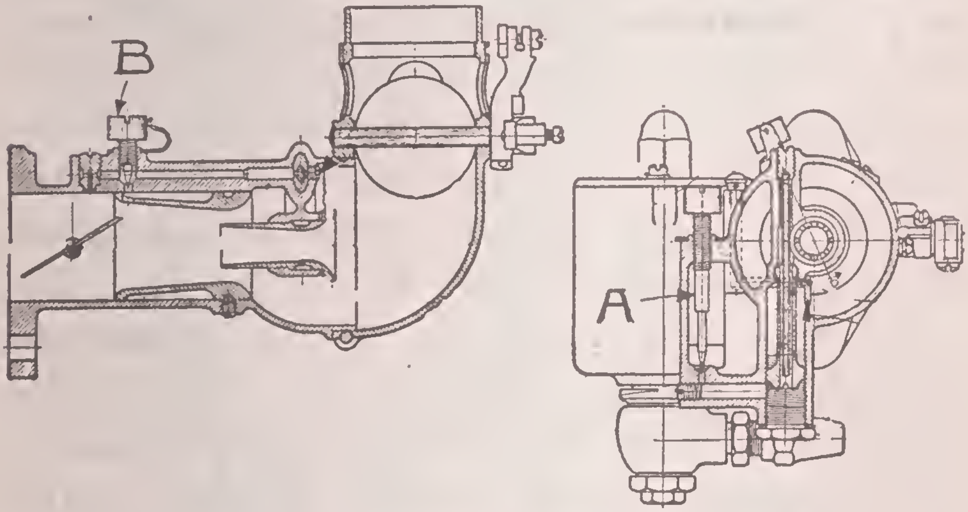


Fig. 82
Stromberg Model M Carbureter

the throttle lever on the steering wheel in a position corresponding to about 20 miles per hour road speed. Then move the pointer clockwise, away from the float chamber, one notch at a time, until the engine begins to slow down, then come back one notch

The MB carburetors shown in Figure 82 has two adjustments, the high speed at A, and a low speed setting similar to that for Model L

Zenith Carburetor, Model O. This carburetor, a cross-section of which is shown in Fig. 83, consists of a float chamber, a carbureting chamber, a system of nozzle and air passages and a hot air sleeve.

Zenith carburetors have fixed air and fuel openings and operate without automatic valves of any kind. With the proper setting once secured it is maintained under all conditions.

Gasoline from the tank enters the strainer body D, passes through the wire gauge D1, and enters the float chamber through the valve seat S. As soon as the gasoline reaches a predetermined height in the float chamber the metal float F, acting through the levers B and collar G2, closes the needle valve G1 on its seat. To see if there is any gasoline in the carburetor remove dust cap C1. If the needle valve can be depressed with the finger there is no gasoline in the carburetor. From the float chamber to the motor gasoline flows through three different channels in various quantities and proportions according to the speed of the motor and degree of throttle opening. With the throttle fully open, most of the gasoline flows through the channel E and main jet G. Some flows through compensator I, then through K to the cap jet H, which surrounds the main jet. The main jet and cap jet work together and their combination furnishes the mixture required for various engine speeds. At slow speed when the throttle T is nearly closed they give but little

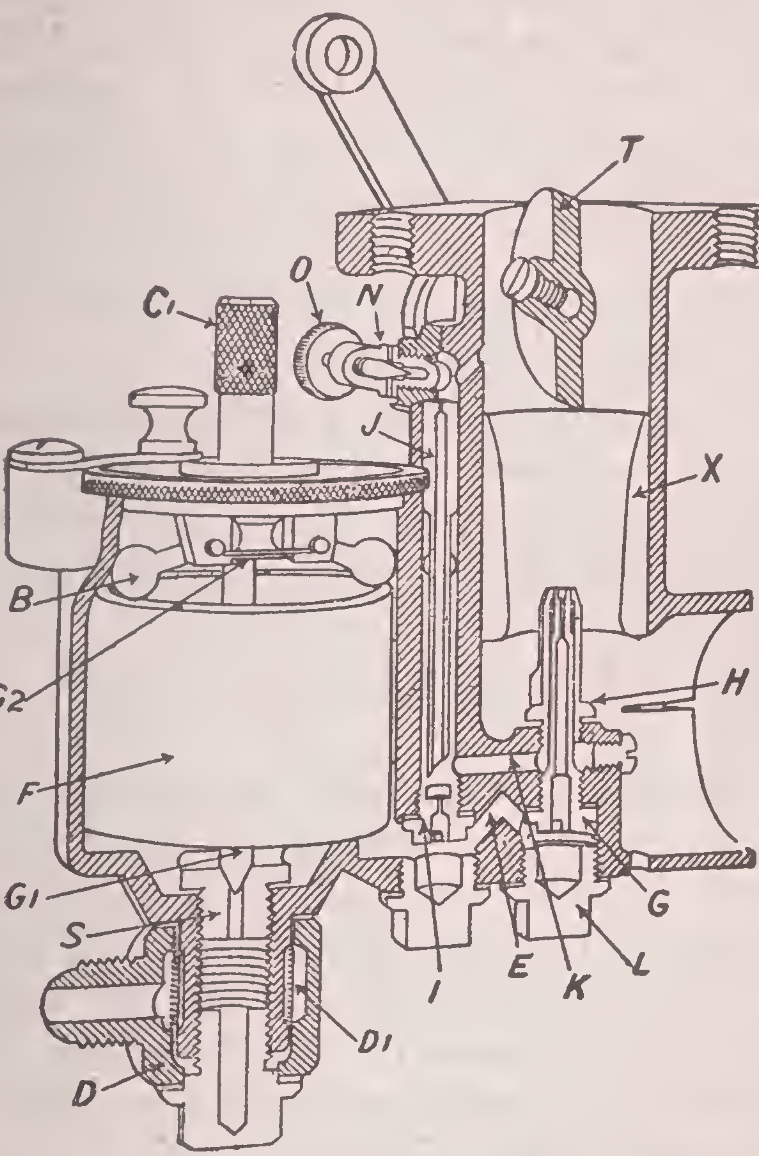


Fig. 83

Zenith Carburetor, Model "O". B, Float Control Lever. C1, Dust Cap. D, Strainer Body. D1, Wire Gauze. E, Gasoline Channel. F, Float. G, Main Jet. G1, Needle Valve. G2, Float Control Collar. I, Gas Well Opening. H, Secondary Nozzle. J, Gasoline Well. K, Gasoline Passage. L, Drain Plug. N, Idling Adjustment. S, Float Valve Opening. T, Throttle. X, Choke Tube.

or no gasoline, but, as there is considerable suction on the edge of the butterfly the tube J, terminating in a hole near the edge of the butterfly, picks up gasoline, which is measured out by a small hole at the top of the priming plug. The well over compensator I is open to the air through two holes, one of which is indicated below the priming plug in the illustration. These air openings are important.

The hot air sleeve is provided with an air strangler actuated by a lever and having a coiled spring to bring it back to the open position. The flexible hot air tubing is attached to this sleeve and feeds the carburetor with air that has been heated by contact with the exhaust pipe.

To start the engine open the throttle a little way. There will be a strong suction on the tube J which will raise the gasoline and thus prime the motor. The only adjustment that may be useful is the slow speed adjustment, which is obtained by the screw O. Tightening this screw restricts the air entrance to the slow speed nozzle, giving a richer mixture.

It is essential that none of the parts shall be tampered with, or the size of the jets altered by reaming or hammering. These jets are tested for actual flow of gasoline and brought to a standard. The nominal size of the hole in hundredths of a millimeter is stamped on the jet: the higher the number, the larger hole.

Variables that can be modified for the initial setting of the carburetor: First, the choke tube X. This choke tube is held in place by set screws and can be removed after taking apart the throttle.

It is really an air nozzle, of such a stream line shape that there will be no eddies in the air drawn through it.

For a 4 cylinder engine whose maximum speed is 1,500 R. P. M., to obtain the choke number, multiply the bore in inches by five and add one to the result.

For 6 cylinder, take a choke one size larger up to 4½" bore and two sizes larger above 4½" bore.

If the engine is so built that it can turn up to 1,800 R. P. M., increase these results 8%; up to 2,000 R. P. M., increase 16%; up to 2,500 R. P. M., increase 25%.

A choke tube too small will cause a loss of charge at high speed, the car will not attain its proper speed.

A choke tube too large will lead to irregularities when slowing down and picking up.

Second—Main Jet C. The effect of this jet is most marked at high speed, 1,400 R. P. M.

Third—Compensating Jet I. This jet, which compounds with the main jet, exerts its maximum influence at lower speeds, 600 R. P. M., and in picking up.

Fourth—Secondary Well P. This regulates the amount of gasoline used when idling.

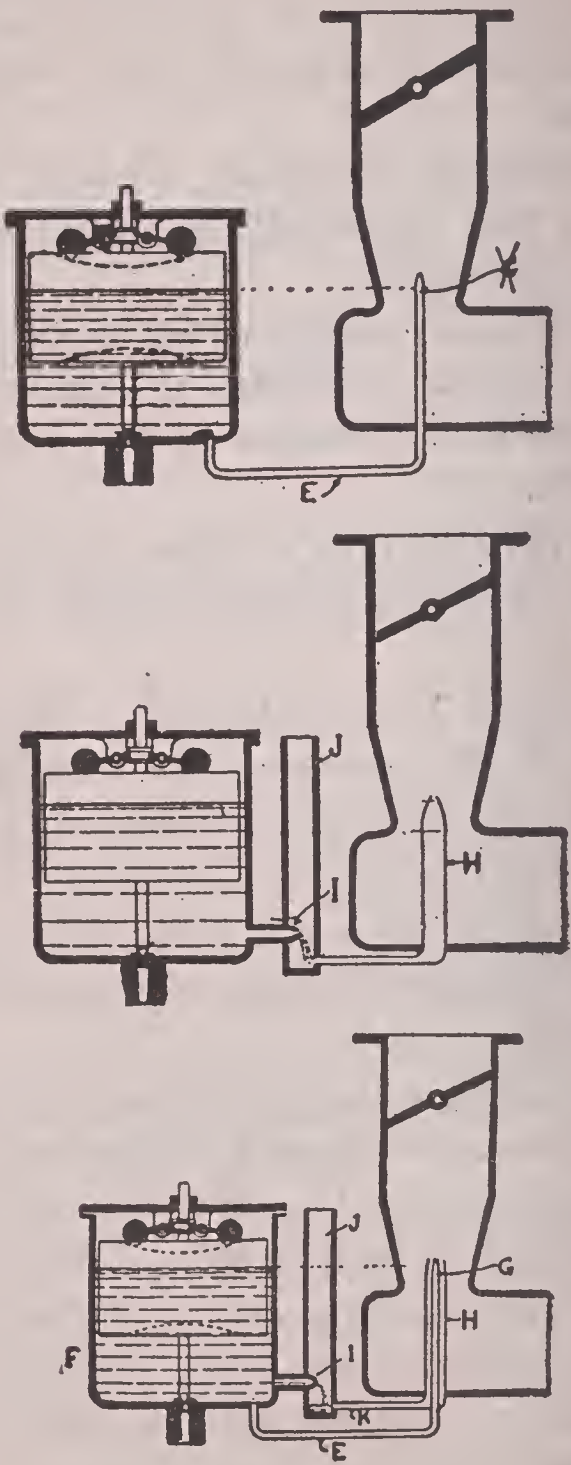


Fig. 84
Principle of Zenith Carburetor

Zenith Carburetor Principle. The principle upon which the Zenith carburetor operates may be understood by reference to Figures 84. The elementary type of carburetor shown at the top consists of a single jet or spraying nozzle placed in the path of the incoming air and fed from a float feed device.

While it might be supposed that, with increase of engine speed, the flow of both gasoline and air would increase in proportion, this is not actually the case. The flow of gasoline increases in almost direct proportion with the engine speed but because the increase of suction or vacuum tends to draw the air out thinner and thinner, the actual quantity of air does not increase in any such proportion and the mixture of gas supplied by such a carburetor would become richer as the speed increases.

Referring to the center drawing in the Figure it will be seen that, between the float bowl and the jet, has been placed a well J which is open to the outside air and through which the gasoline passes by way of the opening I, thence passing as before to the jet H. It will be realized that the maximum amount of fuel that can reach the jet H will be determined by the size of the opening I without regard to the suction existing around H because the flow through I is not directly acted upon by this suction. With such a device the air flow will increase with speed of the engine; and while it will not be in direct proportion, there will be an increase over the whole range of engine speed. Now, inasmuch as the flow of gasoline cannot increase beyond a certain amount, while the flow of air will increase, the mixture furnished by such an arrangement will become weaker with increase of engine speed.

In the Zenith carburetor these two types of jets are combined as shown in the lower drawing. The direct suction, or richer mixture type, leads through pipe E and nozzle G, while the limited flow device consists of the well J, opening I, passage K and jet H. As the flow of fuel from jet H counteracts the change in the flow from jet G, the complete mixture may be made practically of constant proportions over all ranges of speed.

Chain Drive. This form of power transmission, an application of which is shown in Figures 85 and 86, is largely used on motor trucks of large load carrying capacity. The chain drive system makes use of a jack shaft placed crosswise of the car and containing the differential gearing. The change speed gearing is usually attached to this cross shaft. At the outer ends of the driving members of the jack shaft are mounted sprockets and a second sprocket is

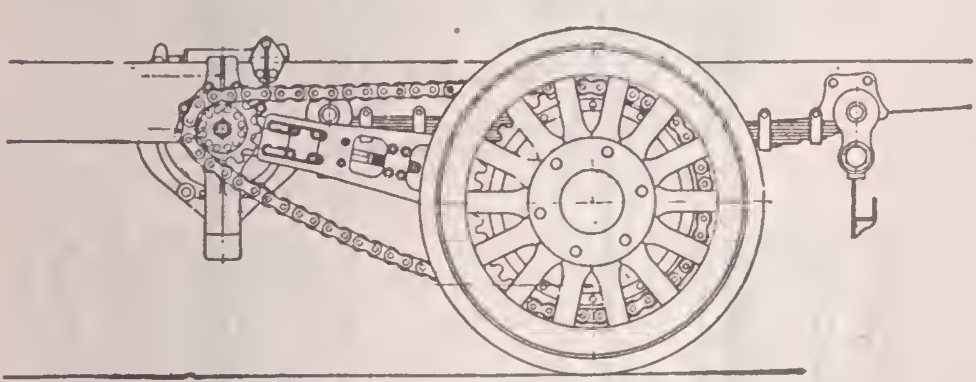


Fig. 85
Chain Drive

fastened to each of the rear driving wheels. Between the two sets of sprockets are placed chains of the roller type. The reduction in speed between engine and road wheels is obtained at two points, the first in the bevel gears of the jack shaft and the second due to the difference in size and number of teeth on the front and read sprockets. The rear axle used with chain drive systems is a simple solid member on the ends of which are carried the wheels. The axle may be of tubular, square, rectangular or "I" beam section.

Chain drive is satisfactory and efficient as long as the chains are kept clean and well oiled. Due to their exposed position this is a difficult

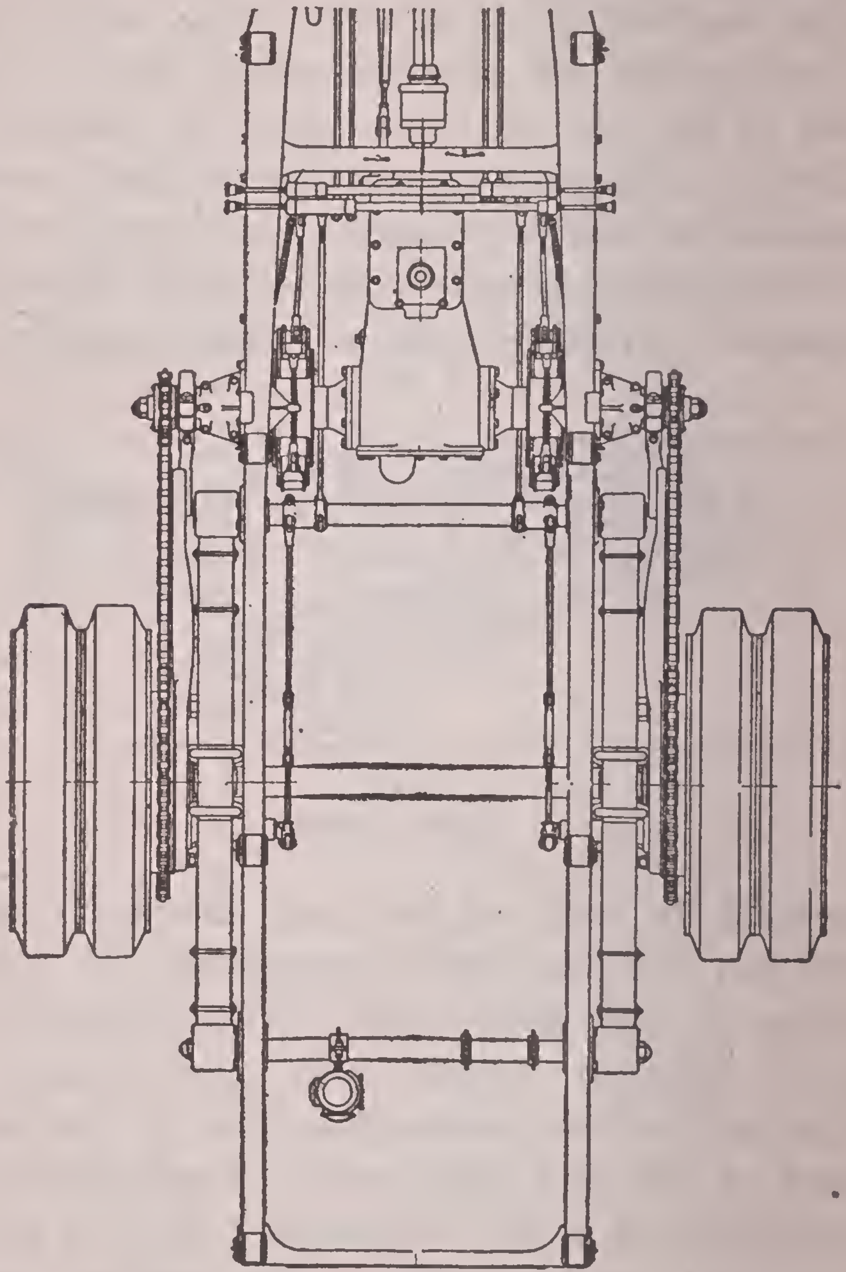


Fig. 86
Chain Drive on Motor Truck

matter and in many cases they have been enclosed in cases of pressed or cast steel.

The roller chains used are described according to three measurements; first the pitch which is the distance from the center of one roller to the center of one adjoining, second the width which is the distance across the opening in the links in which the sprocket teeth engage and third the outside diameter of the rollers, all of these sizes being given in inches.

The distance between the jack shaft sprockets and the wheel sprockets is determined and maintained by means of radius rods which are fixed

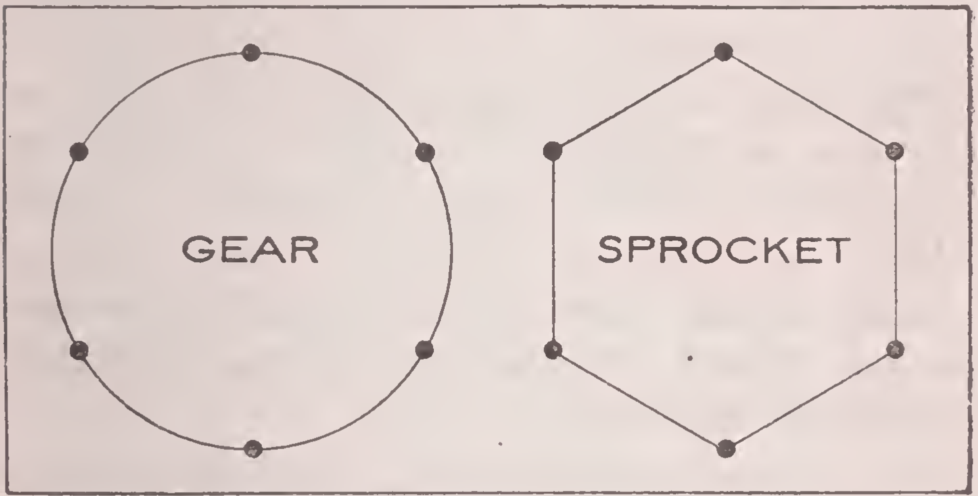


Fig. 87

to the jack shaft and the rear axle by means of swivel joints. These rods are made adjustable for length so that chain wear may be compensated for.

SPROCKETS. The circular instead of the linear pitch is often erroneously used in calculating the pitch diameter of a sprocket wheel. Reference to Figure 87 will illustrate the difference between circular and linear pitch, and help to demonstrate the case more clearly. The view at the left of the drawing shows the circular pitch, and the view at the right the linear pitch of a gear or sprocket wheel respectively. If the circular pitch of the gear be one inch and the gear has six teeth as shown, the pitch diameter will be 6×0.3183, which gives 1.91 inches as the pitch diameter. Let the linear pitch of the sprocket be also one inch, and with six teeth as before. In a sprocket having 6 teeth, the radius is equal to the linear pitch, as the figure is composed of six equilateral triangles, and the pitch diameter of the sprocket wheel is consequently 2 inches.

The pitch of the sprocket must, of course, be the same as that of the chain to be used with it. Chain pitches usually measure in even inches and common fractions. The type of chain, whether roller, block or silent, must also be considered. It is not safe to use mismated chains and sprockets.

Sprockets, Dimensions of. Table 8 gives the pitch diameters of sprockets for roller chain of 1 inch, 1¼ inch and 1½ inch pitch, with 7 to 28 teeth. The outside diameters may be found by adding the diameter of the roller to the pitch diameter of the sprocket.

Sprocket Chain Lubrication. The best lubricant for sprocket chains is a constant puzzle. If oil is used it is absorbed by the dust which settles on the chain. If tallow or other animal grease is employed it is pushed away from the bearing surfaces, and the latter get dry. The ideal lubricant would seem to be something be-

TABLE 8.

DIMENSIONS OF SPROCKETS FOR ROLLER CHAIN.

Number of Teeth in Sprocket.	1 Inch Pitch.	1¼ Inch Pitch.	1½ Inch Pitch.
	Pitch Dia.	Pitch Dia.	Pitch Dia.
7	2.31	2.88	3.46
8	2.61	3.27	3.92
9	2.92	3.65	4.38
10	3.24	4.04	4.85
11	3.54	4.44	5.33
12	3.86	4.83	5.79
13	4.18	5.22	6.27
14	4.50	5.62	6.75
15	4.81	6.01	7.22
16	5.12	6.41	7.69
18	5.76	6.41	8.64
20	6.39	7.99	9.59
22	7.03	8.79	10.55
24	7.66	9.58	11.49
26	8.31	10.38	12.44
28	8.95	11.19	13.42

tween an oil and a grease, too thick to be drawn out by absorption, yet soft enough and clinging enough to stay in the rollers. This mission is approximately fulfilled by a mineral grease, such as non-fluid oil, or Keystone grease, which are not affected by moderate changes of temperature, and have the clinging quality which animal greases lack. The makers of these greases, however, do not recommend heating them, and they cannot be introduced into the links and rollers of the chains, except by rendering them temporarily more fluid than they are desired to be in service. A very good lubricant for this purpose is made by dissolving Keystone grease in gear case oil, in amounts sufficient to produce a viscous fluid at the boiling point, which thickened when cold, and would just barely flow. A fairly liberal quantity of graphite was added, about half a cupful to three quarts of dope, and the chains after cleaning were boiled for half an hour or longer in the mixture to enable it to penetrate thoroughly.

Chains, Tire. Tire chains are almost a necessity under many conditions of driving, but in order to avoid damage to the tires themselves the chains should be properly applied and properly used. Chains should be applied loosely enough so that they can work around from place to place. Always use chains on both rear wheels, never on only one wheel. Make prompt replacement of worn and sharp links, as they will soon cut the casing. Apply the chains so that the rounded sides of the links and clasps come against the rubber. Do not use chains on dry streets, and when they are used take them off as soon as the emergency has passed.

Change Speed Gearing.

The means provided for securing different ratios of speed between the engine and road wheels of the car is oftentimes called the transmission. Strictly speaking, the transmission system includes all the parts between engine and wheels; the clutch, universals and rear axle parts, as well as the mechanism that allows various forward speeds and the reverse. The Change Speed Gear takes various forms; planetary, friction, sliding gear and magnetic, each being described.

CHANGE SPEED GEARS. When a gasoline engine is loaded above a certain limit it slows down, and the intervals of time between explosions in each cylinder become so far apart that the engine begins to labor, and will finally stop altogether, unless some means is provided whereby the revolutions of the engine may be increased without increasing the number of revolutions of the driven shaft, or car axle. This is accomplished by means of the change speed gear, of which there are two classes, viz., those in which an infinite series of variations in speed ratio is possible, and those in which only a comparatively small number of step-by-step ratios can be utilized. In the first class are several styles of belt and friction disc drives, while in the second class are the change speed gears proper, namely, sliding gears, individual clutch gears, and planetary gears.

Belt and friction drives constitute the only practical forms of change speed devices in which variation from the highest to the lowest speed may be possible. In other change speed gears the ratio is changed by passing from one to another in a series of definite steps.

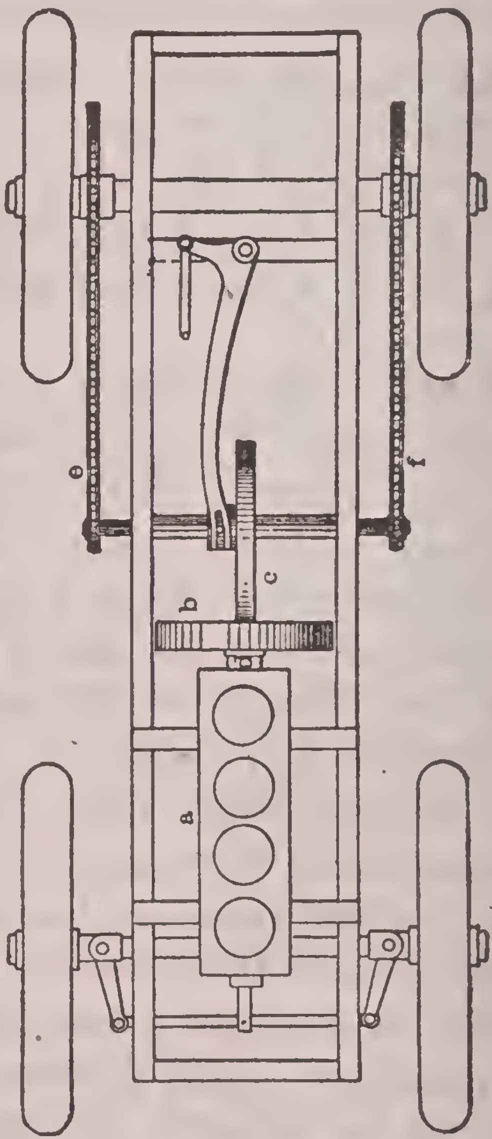


Fig. 88
Friction Disc Change Speed Gear

Friction Drive. One of the most simple methods of changing the speed ratio between the motor and the driven shaft is the friction drive, which in its simplest form consists of two discs at right angles to each other, see Fig.

68, in which b is the fly wheel, the exterior surface of which is made a true plane, and usually covered with a special friction metal. A horizontal shaft located crosswise of the car body carries a friction pulley c, in close proximity to the surface of the fly wheel b.

Friction pulley c while secured from turning on shaft, may at the same time be shifted along at the will of the operator, and thus be brought in contact with any portion of the surface of the flywheel, from its center to its outer edge. The shaft also carries on its outer ends, the sprocket wheels which drive chains e and f, by means of which the power is transmitted to the drivers. In this device if the friction pulley c be brought in contact with the exact center of fly wheel b, no motion will be imparted to c, but if it be moved outward from the center of the flywheel it will revolve, the number of revolutions it makes being governed by its distance from the center. The maximum speed is attained by friction pulley c when it is brought into contact with the surface of the fly wheel near the periphery of the latter. All positions of friction pulley c upon one side of the center of fly wheel b impart a forward motion to the car, and all those on the other side of the center impart a reverse, or backing motion. The traversing movement of pulley c along its shaft is usually produced by a hand lever provided with a notched quadrant, whereby the pulley is held at all times in some one of the many positions giving graduations of speed. The method usually employed for making and breaking contact between the friction pulley, and flywheel face, consists in mounting the bearings of the cross, or countershaft in swinging brackets. Another method is to mount these bearings in eccentric housings, a slight rotation of which in the bearing brackets will cause the shaft and with it the pulley to approach, or recede from the face of flywheel b. The movement of the shaft toward, or away from the flywheel is produced by a ratchet retained pedal through a reducing linkage, which multiplies the foot pressure.

Double Disk Friction Drive. The limitation of the single disc and wheel to small power, and light loads, has led to the development of the double disc, double wheel type of friction gear illustrated in Fig. 89.

The engine shaft is extended, and carries two disc fly wheels A and B, while friction pulleys C and D are each carried upon one half of the cross shaft which is divided at its center. Friction pulleys C and D are made to slide along the shafts H and F, and are controlled by a common sliding mechanism, so that they always bear upon points of discs A and B, having the same velocities. Driving contact is effected by swinging shafts H and F in a horizontal plane, and it is obvious that if one of the pulleys, D for instance, is pressed against the face of A, it will revolve in one direction, while if brought to bear on B it will revolve in the opposite direction, thus providing for a go-ahead, or a back-up motion being imparted to either friction wheel at will, dependent upon whether it is in contact with the forward, or the

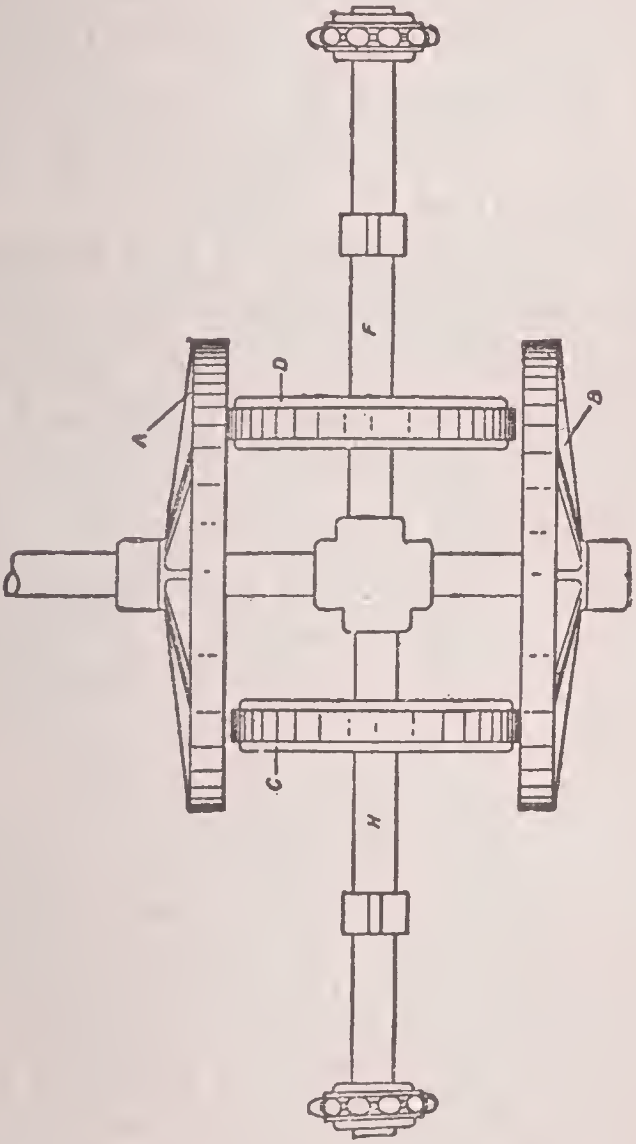


Fig. 89
Double Disc, Double Wheel Change Gear

rearward disc. It is also evident that if one of the wheels, say D, is pressed against A, and the other wheel C is also pressed against B, their shafts will rotate in opposite directions. The ratio of the common angular velocity of the wheels and their shafts to that of the discs is in proportion to their distance from the center of the discs. Sprockets upon the extremities of shaft H and F drive the road wheels by chains, and sometimes no differential is employed, power being shut off when turning corners, or, if not, the inevitable slip is divided between the frictional contacts, and the contacts of the tires with the road. A differential may be mounted in either shaft H or F at will.

Instead of the two shafts H and F being separate, they may be joined to form a continuous shaft and pivoted in the center. The shaft as a whole is capable of being slightly swung in a horizontal plane about its center, so as to bring friction wheel D in contact with one disc, and friction wheel C in contact with the other, thus producing either the forward or reverse drive. In this case a single sprocket is carried by the shaft and drives a live rear axle.

FRICTION DRIVES—MATERIALS FOR. In friction drives, one of the surfaces in contact is generally a metal, while the other surface is composed of some kind of organic material, of a slightly yielding or conforming nature. Cast iron with cork inserts may be used for the metallic surface, the cork inserts serving to increase the co-efficient of friction, besides absorbing any oil that may accidently reach the surfaces. Aluminum is no doubt the best material for the metallic surface, on account of its plastic nature. Copper also possesses similar properties. For the non-metallic surface, leather is good so long as oil is kept from accumulating on it, but its co-efficient drops rapidly as soon as oil gets between the contact surfaces.

Some kind of vegetable fibre, made into a paper or mill board, seems to be the preferred material, and it is common to treat such paper with a tarry composition, which tends to raise the co-efficient of friction, as well as to render its value more nearly constant under the influence of water and oil.

The non-metallic friction face is the one worn out in service, or at least it wears the more rapidly. This part of the combination, though of limited life, can be renewed at a comparatively small expense, and it fails only after giving due notice. It is the practice to make the disc face metallic, and the friction wheel rim non-metallic. Great care should be exercised in starting the car, as at such times the disc is liable to slip at speed upon the rim of the friction wheel which is then either stationary or revolving very slowly, and flat spots may very easily be worn upon its surface.

THE PLANETARY CHANGE SPEED GEAR. This system of transmitting the power at various speeds comprises a high-speed connection for the direct drive, and an arrangement of gears that reduces or reverses the motion when one or another drum on which these gears or pinions are mounted is held stationary. Most planetary systems give only two forward speeds and the reverse, but in some instances they are made to give three forward speeds. They are used chiefly on small automobiles, or runabouts; but when cheapness of construction is an object they are sometimes employed on touring cars.

In Fig. 90 is shown one form of planetary system. The gear a is the only one keyed to

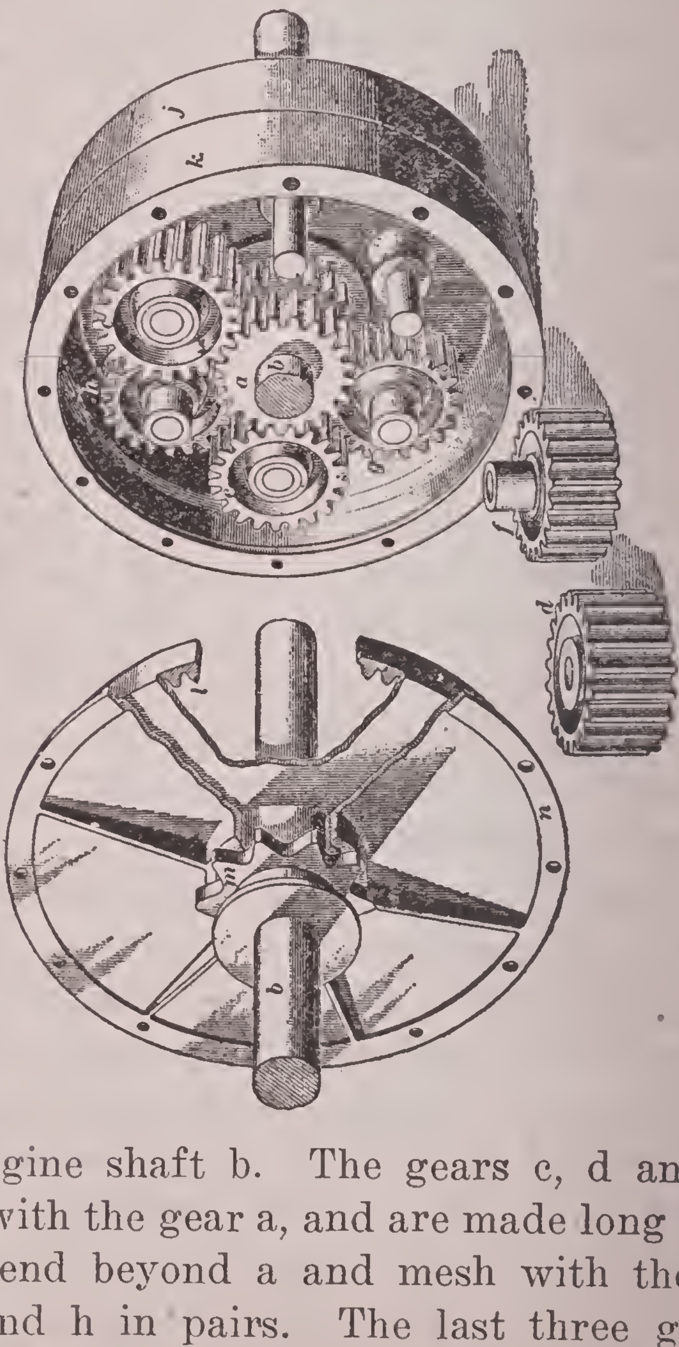


Fig. 90
Planetary Gear

the engine shaft b. The gears c, d and e all mesh with the gear a, and are made long enough to extend beyond a and mesh with the gears f, g and h in pairs. The last three gears in turn extend beyond the gears c, d and e, and mesh with the gear i, which is keyed to a sleeve connected to the drum j. The gears c, d, e, f, g and h turn on pins fastened to the drum k, but only the gears c, d and e mesh with a, and only f, g and h mesh with the gear i which turns loosely on the shaft b. The internal gear l meshes only with the gears c, d and e, and is rigidly connected to the sprocket m that drives the automobile. The cover n is attached to the face of the drum k by means of screws, thus forming an oil reservoir that keeps the gears well lubricated when the automobile is running. There are separate brake bands around the drums j and k, and a friction disc keyed to the shaft just outside of the drum j.

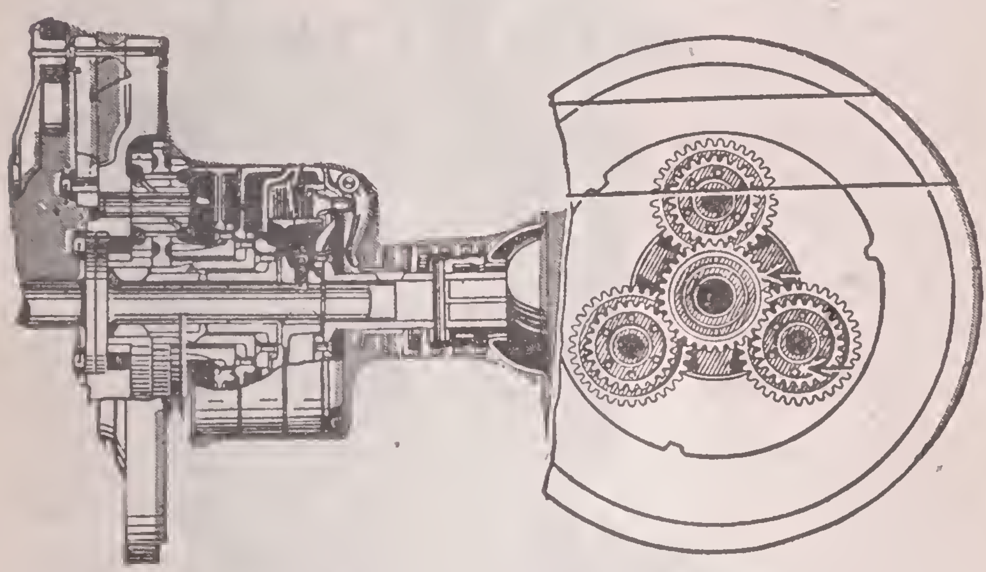
When the friction disc is pressed against the drum j, the gear is held so that it must turn with the shaft; consequently, the entire mechanism is locked together and the sprocket m turns at its highest forward speed. If now the friction disc is released and the brake band around the drum j is applied so as to hold it from turning, then the gear a turns the gears c, d and e, causing them to turn the gears f, g and h; but, as the gear i is held stationary with the drum j, the gears f, g and h, and also the drum k, to which they are attached, must revolve around the gear i in the same direction as the shaft turns, but more slowly. The gears c, d and e turn on pins that are fastened to the drum k; consequently, they revolve with it as they turn on their axes and thus cause the internal gear l and the sprocket m to turn in the same direction as the shaft. This gives the slow forward speed.

When the drum j is released, and the drum k is held by a brake band, the gears c, d and e are caused to turn on their pins, and consequently drive the internal gear l in a direction opposite to that of the engine shaft, driving the automobile backwards. When the brake bands and friction disc are all free from the drums, the gears turn idly, and if the engine is running, no motion is transmitted to the sprocket and the automobile stands still.

Ford Planetary Change Gear. The gears in the Ford transmission are arranged as shown in Figure 91 and all of these sets revolve around the main shaft. This device uses all spur gears, that is, gears having external, rather than internal, teeth. As in other planetary drives the speed ratios are secured by stopping the movement of certain gears which are carried on parts attached to cylindrical drums. Bands, similar to brake bands, act on these drums to stop their rotation, the tightening of any band stopping its corresponding drum and bringing the required gears into action.

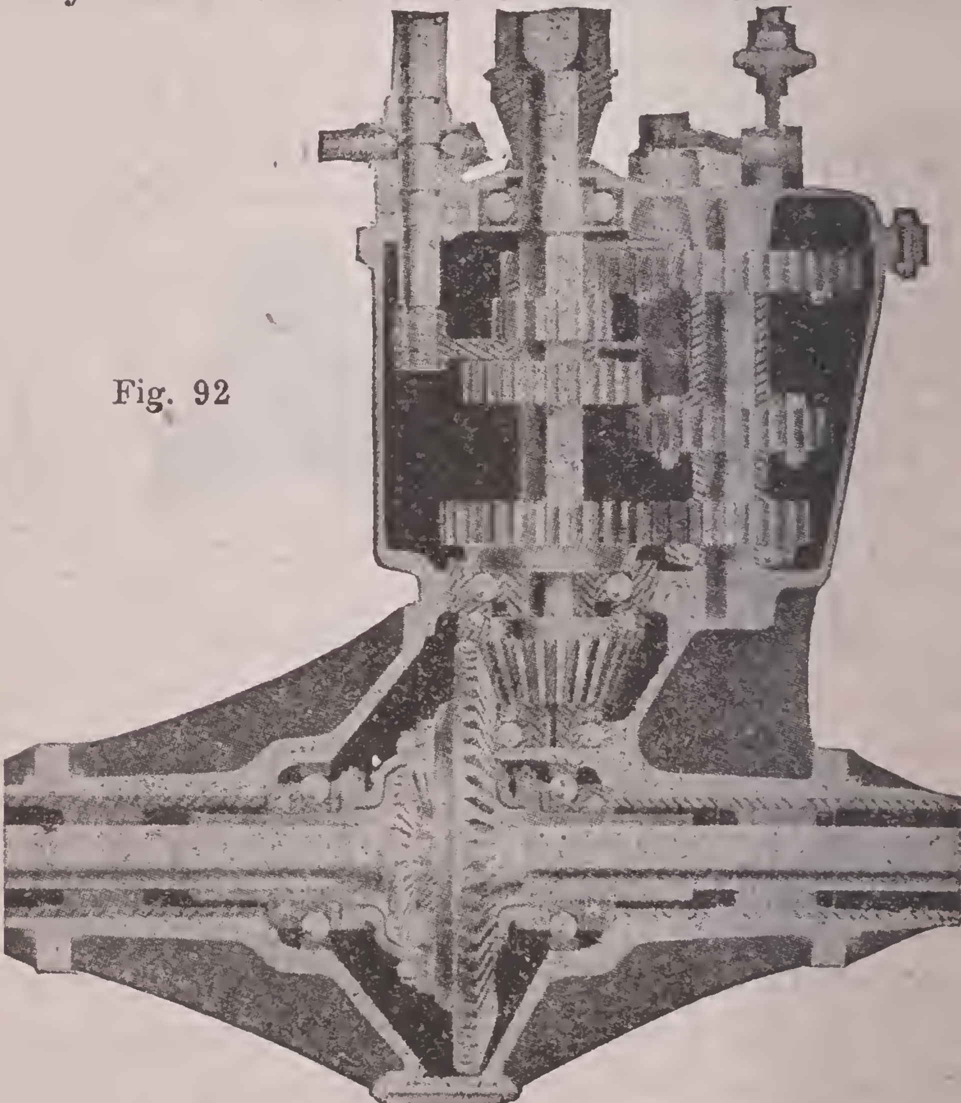
Mounted with their centers in line with the main shaft of the transmission and in line with the crankshaft of the engine are three gears, two of which are attached to two separate drums while the third is called the driven gear and is attached to the shaft through which the rear axle is driven. These three gears vary in size but are all fastened together so that they rotate at the same rate of speed and as a unit. In mesh with these gears and spaced equi-distant around their circumferences are three sets of three gears each.

When it is desired to start the car from a standstill, a pedal is pressed which causes one



of the drums to stop revolving. This drum is attached to one of the gears of the three on the main shaft. The pins or axles of the three sets of three gears are fastened to the flywheel of the engine so that when the engine is running the sets of gears are carried around on the outer edges of the gears which are mounted concentric with the shaft. Because of the fact that the one gear being held by the band and drum is standing still, the sets of three gears must turn around their own centers in traveling around the outside of this center gear, and, depending on the relative sizes of the stationary gear and the gears traveling around it, a motion is imparted to the driven gear on the shaft, which may be either forward or backward.

Fig. 92



CHANGE SPEED, SLIDING GEAR TYPE.

A form of change speed gearing that is in use on a large majority of cars is that known as the sliding gear. All sliding gear transmissions consist of two principal shafts lying parallel to each other and placed one above the other or side by side. Each shaft carries a series of gears, those on one shaft being permanently fastened against lengthwise movement, while those on the other shaft are capable of being moved along the shaft while turning with it. This latter set of gears is built with either a square or key-wayed hub and the shaft on which the set slides is made square or with spline keys to correspond. The gears on the other shaft are made of such sizes that when the sliding members are moved they come into mesh with the gears on the other shaft so that when together they form pairs, that is to say, when a gear on one shaft is in mesh with one on the other shaft it is impossible to cause any other gears to mesh at the same time.

The gears are graduated in size so that the several pairs or combinations that may be formed vary in ratio, and in this way it is possible to obtain different degrees of speed reductions between the two shafts and therefore between the engine and road wheels.

In forms of construction that use the two shafts exactly as described in the previous paragraphs, and in which one shaft is connected through the clutch to the engine and the other one through the drive parts to the rear wheels, the series of sliding gears is made with all of the gears fastened together so that there can be no relative motion between them, and in this

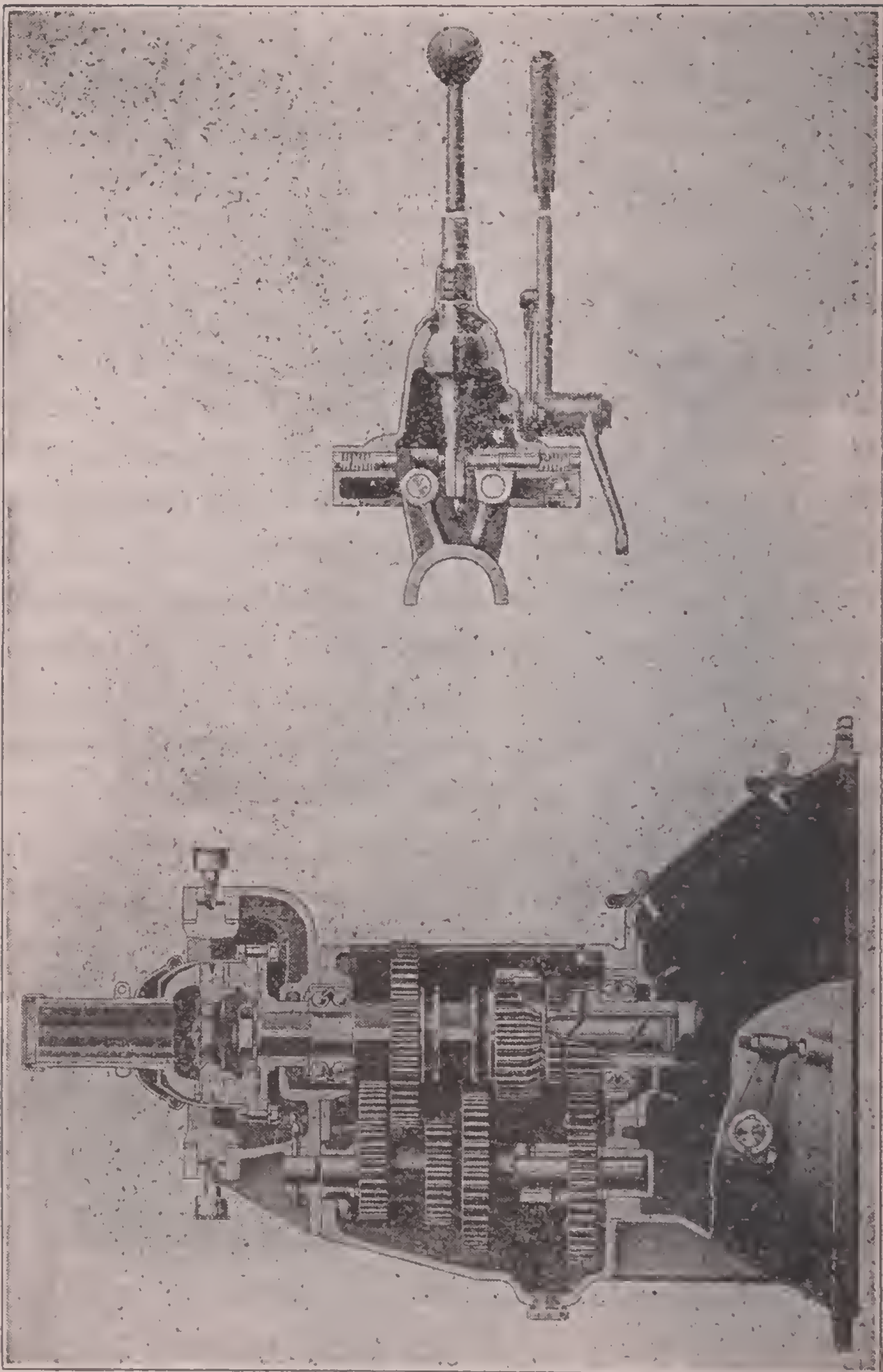


Fig. 93
Selective Sliding Change Speed Gears

case the entire sliding member is moved bodily along the shaft. This particular form is known as a progressive sliding gear. It is necessary, with this type of construction, to pass from one ratio to another in the same order for each operation, and if it is desired to pass from the extreme low ratio to the highest ratio, it is nec-

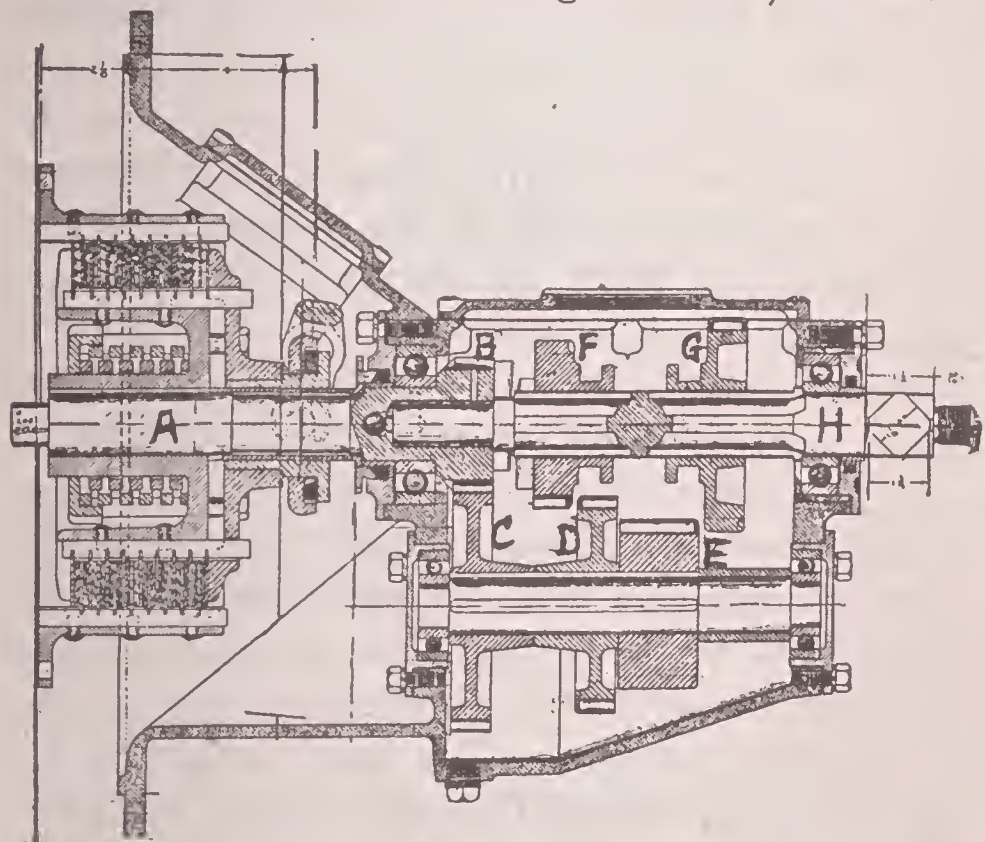


Fig. 94

Selective Sliding Gear With Disc Clutch in a Unit Power Plant. A, Clutch Shaft. B, Clutch Shaft Gear. C, Countershaft Gear. D, Second Speed Gear. E, Low Speed Countershaft Gear. F, Second Speed Sliding Gear. G, Low and Reverse Sliding Gear. H, Sliding Gear Shaft.

essary to pass through all intermediate ratios. The progressive form of transmission is no longer fitted to cars and an extended description is not considered necessary

The type of sliding gear transmission that is most popular is called the selective sliding gear and with the exception of some important modifications is similar in operation and construction to the progressive type already described. Selective sliding gears are shown in Figs. 92 to 97 and the following description will apply more or less to all of them although the form shown in Fig. 94 is specifically covered. It will be noted that the clutch is at the left hand end of the illustration, and through this clutch the power of the engine is transmitted to the shaft marked A. At the right hand end of the shaft A is carried a gear B, and this gear is in mesh with the gear C on the lower shaft of the transmission, it will therefore be seen that whenever the clutch causes shaft A to revolve, gears B and C will also turn, and inasmuch as C is fastened solidly to the lower shaft of the transmission, this lower shaft will turn whenever the engine is running and the clutch engaged. The upper shaft in the transmission marked H is not made in one piece with shaft A, but its left hand end is made of a diameter sufficiently small to fit into a recess in the shaft A and in the hub of the gear B. This construction simply provides a bearing for one end of the shaft H so that it may revolve independently of shaft A. Shaft H is formed with four longitudinal keys integral, and on this shaft are mounted the gears F and G with their hubs formed with keyways to engage the keys on shaft H. This construction allows the gears F and G to be moved lengthwise while turning with the shaft. Gears D and F are made of such diameter that when F is moved to the right it meshes with D and gears E and G will mesh when G is moved to the left. The right hand end of shaft H is fastened to the universal joint that leads to the rear axle.

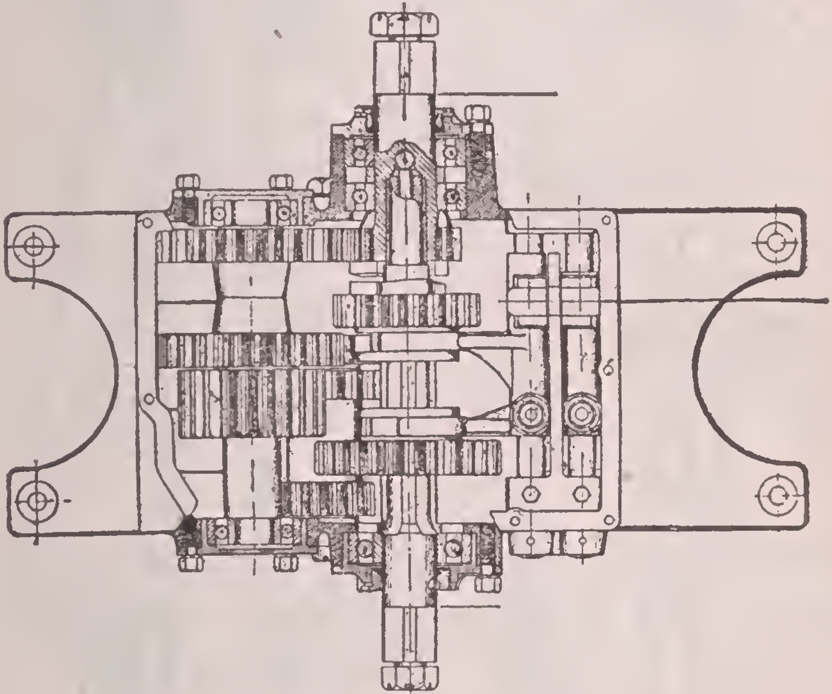


Fig. 95
Sliding Gear Set for Separate Mounting

The operation is as follows: With the engine running and the clutch engaged, power is transmitted through gears B and C to the lower shaft of the transmission, and inasmuch as gear C is larger than B, the lower shaft will run at a lower rate of speed than the clutch shaft. If now the gear G be caused to mesh with E, the shaft H will be revolved but at a still lower rate of speed than the bottom shaft.

and inasmuch as H drives the rear axle it will be seen that the mechanism has given a positive drive at a speed much below that of the engine.

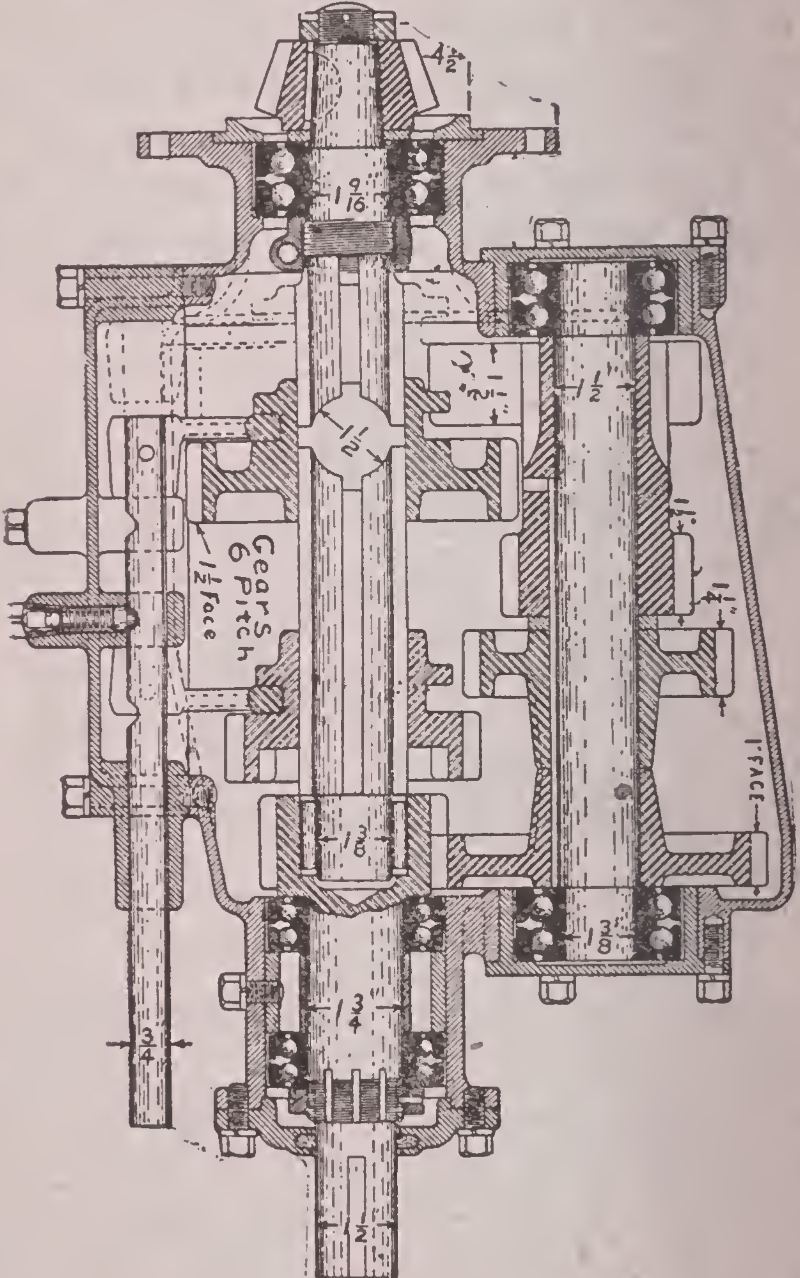


Fig. 96

Heavy Duty Selective Sliding Gear for Rear Axle Mounting

When it is desired to secure a higher speed of the car relative to that of the engine, gears

G and E are withdrawn from each other and gear F is moved into engagement with D. It will be noted that gears D and F are approximately the same size, and the upper shaft will then turn at a speed very nearly the same as that of the bottom shaft, but still less than the speed of the engine. This position is known as second speed or intermediate speed.

When it is desired to secure a still higher ratio of speed it is done by moving gears D and F out of engagement and then moving F to the left. Gear F carries one-half of a jaw, or toothed clutch, and gear B carries the other half of this same clutch. It will thus be seen that when F and B are together the clutch will be engaged and shaft A will drive shaft H at the same speed at which A is revolving. This provides high speed or direct drive.

When it is desired to reverse the direction of motion of the car, gear G is moved into engagement with an idler gear that is not shown, and this idler gear is driven through another one on the bottom shaft of the transmission. The idler gear being interposed between the upper and lower transmission shaft gears causes the upper shaft to reverse its previous direction of motion.

Certain variations of selective sliding gears are in use, one of which is shown in Fig. 97. In this particular form the spur gears remain in mesh at all times, but neither set is keyed to its shaft. Between the gears are mounted jaw clutches, and these clutches are keyed to the shaft. In place of moving the gears into or out of engagement, the jaw clutches are moved, and depending on which clutch is moved and which way it is moved,

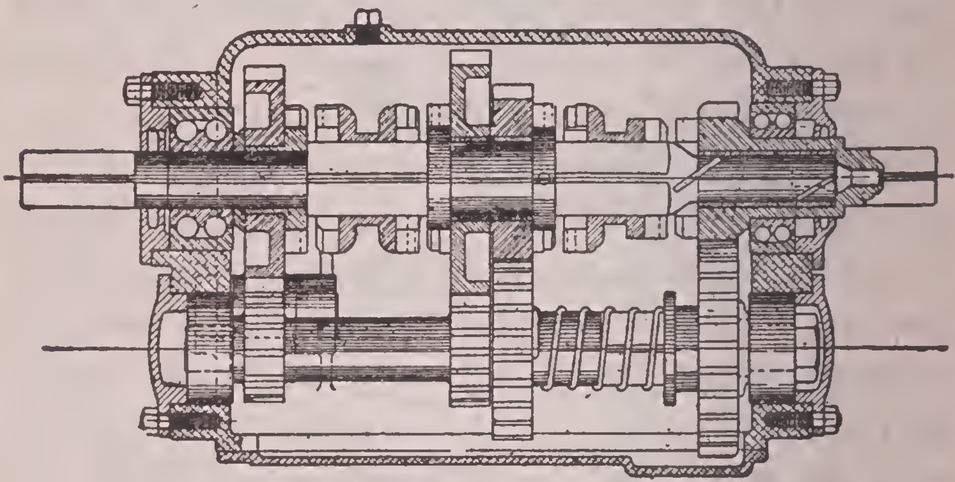


Fig. 97
Individual Jaw Clutch Sliding Gear Set

the several sets of gears may be successively used, providing speed ratios similar to those in other forms of selective sliding gears.

TRANSMISSION OF POWER—EFFICIENCY OF. Two-chain drive, from motor to speed-change gear, from speed-change gear to rear axle—75 per cent.

Quarter-turn or right-angle drive, with double-chain drive to free rear wheels—70 per cent.

Longitudinal shaft drive, with universal joints and bevel gear in differential case—65 per cent.

GEARLESS TRANSMISSION. This name has been applied to a wide variety of transmission, or change speed devices. It is quite customary to refer to the friction drive as a gearless system, and this is true to the extent of not using toothed gearing of any form.

A car using this name was built several years ago, and its construction embodied a novel method of change speed mechanism. The transmission system of the gearless car made use of a central cone, long in proportion to its diameter, and faced with friction material. Placed so that they might engage with this driving member, were several sets of rollers, which were, in turn, brought into contact with driven members or clutches. The principle of operation was that of the planetary, or internal epicyclic, gear. In place of using toothed gears, this car secured its drive by bringing one or the other sets of rollers into play and thereby secured three forward speeds and one reverse. Large power was transmitted and little trouble found.

Magnetic Transmission.

The difference between a car with magnetic transmission and other gasoline cars lies only in this transmission. There is no change in the engine or its operation. There is no change in the driving parts, save as regards their connection with the power. The parts omitted are the clutch and the clutch pedal, gears and shifting lever, flywheel, starter and lighting system, this one transmission unit taking the place of all. There is no mechanical connection between the engine and the driving shaft. This

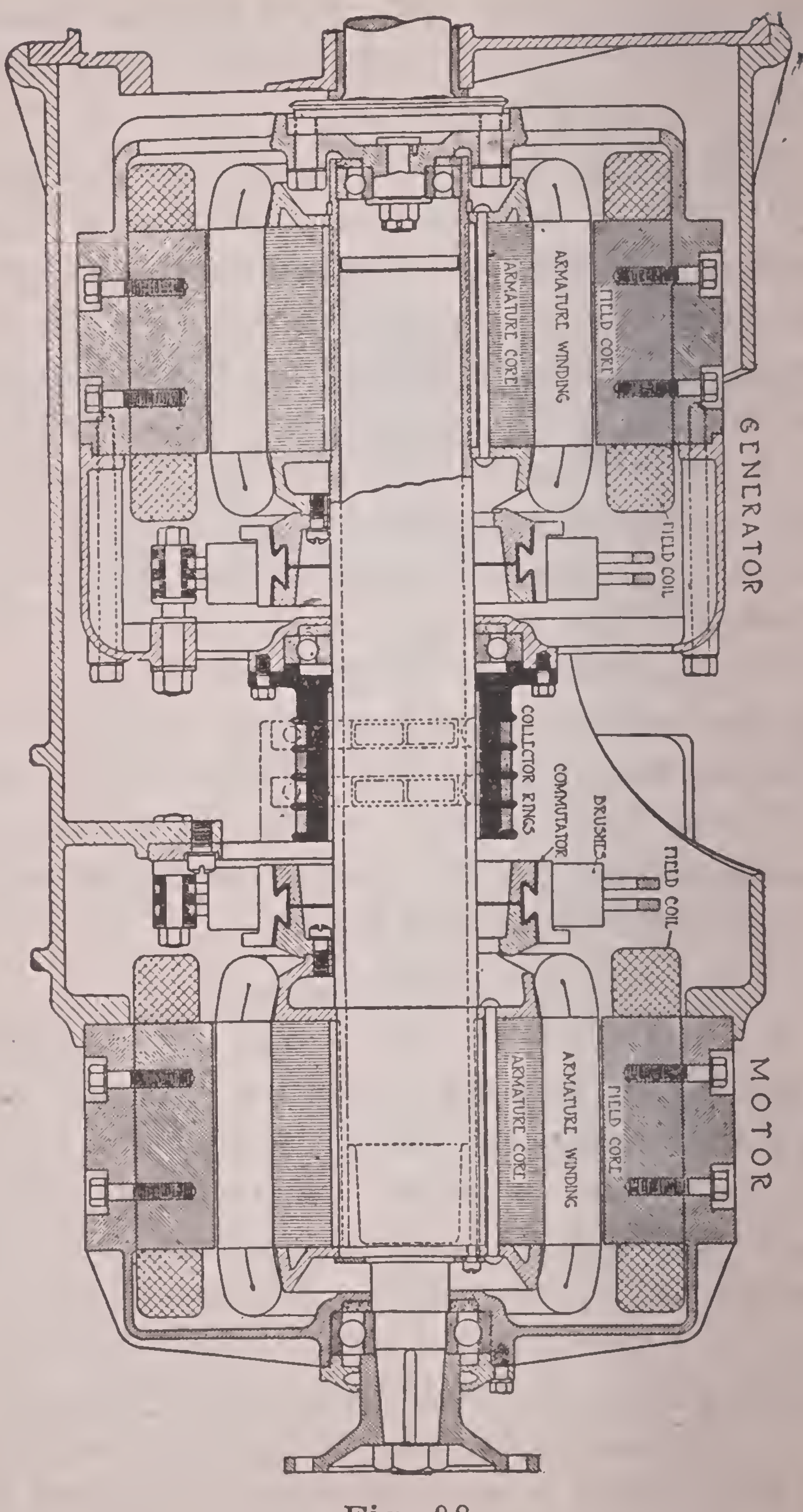


Fig. 98
The Owen Magnetic Transmission

control also embodies an electric brake, and an automatic electric sprag, which absolutely prevents the car backing down hill, even though the motor is stalled. Should the engine be stalled on a hill, the car can be held without use of the brakes by simply moving this control lever into high speed position.

The power is never disconnected from the driving wheels of the car from the moment of starting up to the highest speed.

The electrical apparatus consists of two units, Fig. 98, contained in a one-piece construction: the one nearest to the engine has its magnetic field pieces keyed to the engine crankshaft and acts as a flywheel to the engine. Its armature is mounted on the propeller or drive shaft, hence it will be seen that both these parts can revolve. The second unit of the apparatus has stationary magnetic fields and its armature, as in the first case, is mounted on the propeller shaft. The first unit becomes in turn a dynamo, magnetic clutch and a motor, the second unit, a motor and dynamo.

A controller, with resistance coils internally contained, is bolted to the chassis frame forward of the dash, alongside of the engine, and is operated by a lever on the steering wheel through a small gearing at the bottom end of the steering column.

By placing the control lever in the position "cranking," a battery is connected through the first unit, which in this instance becomes a motor, and once the engine is cranked, the lever can be placed in the "neutral" position until ready to start the car.

On moving the control lever to the first position, turning effort is produced by weakening, with a shunt resistance, the field of the first unit, which becomes a dynamo, and

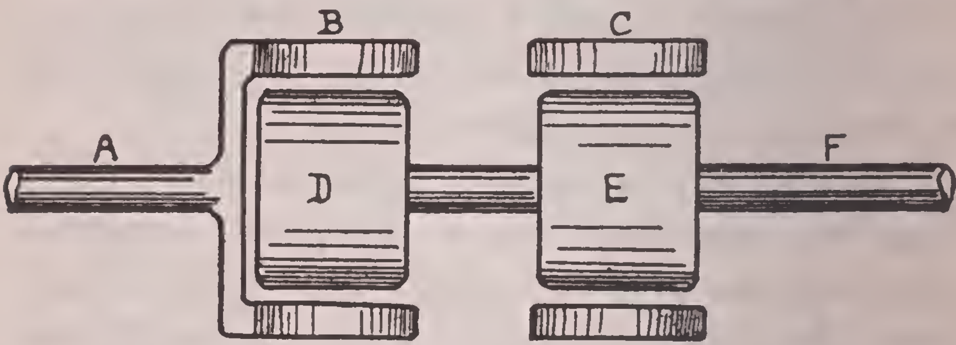


Fig. 99

Principle of the Magnetic Transmission: A, Engine Crankshaft. B, Revolving Field. C, Stationary Field. D, Front Armature. E, Rear Armature. F, Propellor Shaft.

the current generated, due to the electrical slip between the magnetic fields and the armature, is fed to the second unit, which, acting as a motor, produces a powerful starting torque. At the same time the pull of the magnetic fields of the first unit acts as a magnetic drag on its armature, and thus two forces assist in rotating the propeller shaft, which, through the bevel drive, communicates power to the road wheels.

The second position of the control lever cuts the resistance out of the first unit (dynamo) field and shunts through a high resistance some of the field current in the second unit (motor), thereby increasing the speed of the car.

In the third, fourth and fifth control lever positions, the second unit (motor) field is successively weakened until in the sixth control lever position, the field current is almost entirely shunted, so that previous to placing the control lever in the seventh (and last) position, the second unit is practically of itself not doing any work, apart from the fact that there is very little slippage between the first unit (dynamo) field and armature, resulting in generating of but small current. In other words, the drive shaft is being carried around almost entirely by the magnetic drag of the first unit's field on its armature. It will hence be seen that there is an electrical balance in effect throughout the entire sequence of operations.

On placing the control lever in the seventh position, the first unit becomes what may be termed a "magnetic clutch," the armature and field are closed-circuited, and an almost negligible slip only is required to generate sufficient current to enable the field to drag its armature around with it.

The second unit with the control lever in high speed position becomes a generator, and when the car is running, charges the lighting and starting battery with a predetermined charge.

From this point on the entire control is brought about by accelerating or decelerating the gas engine, the armature of the first unit follows its magnetic field promptly, generating of its own accord whenever necessary more current and hence getting more magnetic drag to bring it up to the same speed as the magnetic fields. Thus, so long as the control lever is in any position other than neutral on accelerating, an increase of speed is obtained, but on decelerating, the car coasts just like an ordinary car with the clutch released. This is brought about by the armature of the first unit traveling faster than the fields, and thus not generating any current until such a time as the car comes back to the speed, where the armature of the first unit is traveling at the same or slightly lower speed than the field pieces or the engine, when again current is generated and the drive taken up as before.

Should excessive grades be encountered where extra torque may be desired, the placing of the control lever in a lower position will give the desired result, and naturally by increasing the engine speed with the control lever in a lower position than high, more current will be generated, due to the extra electrical slip, and thus give added torque.

At neutral position the maximum electrical braking effect is obtained. Here the first unit is open-circuited and the second unit closed-circuited and the magnetic braking reaction brakes the car to 10 miles per hour, below which speed the armature does not revolve within the motor field fast enough to create the braking effect, thus automatically holding the car on a grade at about the above speed.

Chassis. The word chassis since its adoption into the English language, is taken to mean the frame, springs, wheels, transmission and in fact all mechanism except the automobile body. In its original French it does not mean all this, but is strictly restricted to mean the frame, or the frame and springs.

Chauffeur. This term when literally translated means the stoker or fireman of a boiler. The use of the word has been extended to the operator of a motor car, but does not usually refer to the paid driver, who is generally known as the mechanician or mechanic.

Clutch. Clutches may be classified as follows: a, cone; b, disc; c, band; cone clutches may, in turn, be subdivided as follows: a, metal to metal; b, leather faced; c, cork insert; while disc type may be classed as: a, leather faced; b, multiple disc; c, cork insert; and band clutches may be put down as of the a, constricting, b, spiral, or c, expanding types. Clutches, of whatever type or class, have but one prime object, i.e., to enable the operator to start and stop the car without having to stop the motor. There is a secondary consideration, if we take into account the fact that it is convenient to be able to slip the clutch, on occasion. Some types lend themselves to this secondary purpose with greater facility than others, and it is also true that some clutches are most easy of application, all things considered.

As clutches are at present designed, the question is, can slipping be tolerated? or, can clutches be slipped to control the speed of a car? It is believed not. The average clutch has very little of the character of the average braking system, and when it comes to brakes they do not last so long that it is desirable to wear them out sooner than they will naturally need replacement. In other words, it seems quite out of the question to consider the clutches of today as suitable for the double purpose of clutching and speed controlling, by way of slipping the clutch at will. It is not uncommon to hear autoists talking of the multiple disc clutch as one that undergoes little or no deterioration as a result of continuous slipping under variations of load.

They seem to think that the large surface exposed, especially in view of the fact that the discs are submerged in oil, will prevent damage if the clutch is caused to slip. They forget that the discs are thin, and also that they are loose on the splines, keys, or feathers that prevent the discs from rotating. No member keyed onto a shaft will stand much abuse. This is especially so, if the member has but little bearing surface on the key. Even a considerable number of such members working in unison will fail to stand up under the work because the joint is not firm. Lost motion is bound to result in more lost motion in a short while, and in a multiple disc clutch the discs soon fray out and interfere with each other, and with the clutching functions, within a space of time so short as to surprise even those most experienced in the use of this type.

Band Clutch. A band, or friction ring, clutch, is shown in Fig. 100. The wheel which is connected to one of the shafts is shown at a, and the band, or ring which is connected to the other shaft and which is made in two parts, is shown at b and c. At d and e are curved arms

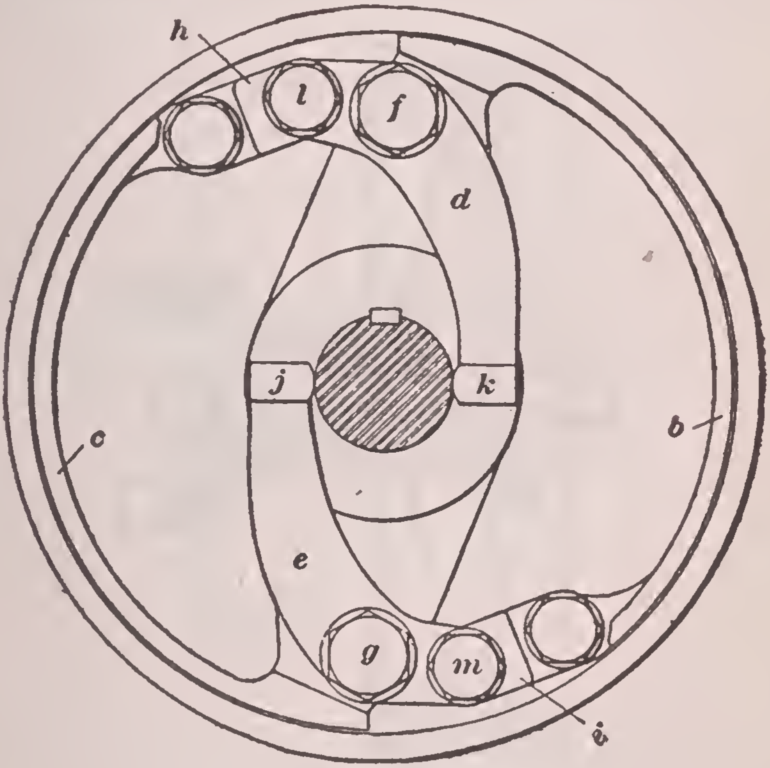


Fig. 100

pivoted at f and g. The links h and i connect these curved arms to the parts b and c of the band. By means of a fork, and tapered sleeve, not shown, the ends j and k of the arms are forced apart when the clutch is brought into use. This throws toward the shaft the ends l and m of the levers d and e, and brings the two parts b and c of the clutch ring in contact with the friction or driving surface of the wheel a, which is thereby forced to turn with the driving shaft. The band clutch has had many exponents in the motor car art, but is open to centrifugal effects to such an extent that it requires considerable ingenuity to overcome troubles arising therefrom. At high engine speeds the operating levers have been so arranged as to lower the normal expanding pressure.

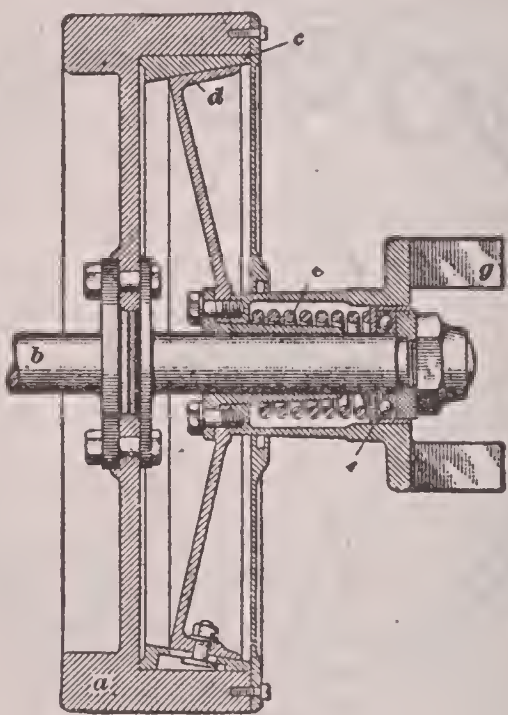


Fig. 101

Cone Clutch. There are a number of modifications of this type of clutch, the general principles of which are illustrated in Fig. 101. The flywheel a is secured to the shaft b by means of bolts through the web of the wheel. At c is an expansion ring into which the friction cone d fits. The helical spring e holds the cone against the expansion ring with the required amount of force. At f is a ball bearing that takes the end thrust when the cone is pulled away from the expansion ring.

The arms g are coupled to the shaft that turns with the friction cone. Ordinarily the two parts of the clutch are held together by the pressure of the spring, and when it is desired to disconnect the cone, a foot pedal is forced down so as to act on a fork and sleeve and pull the cone

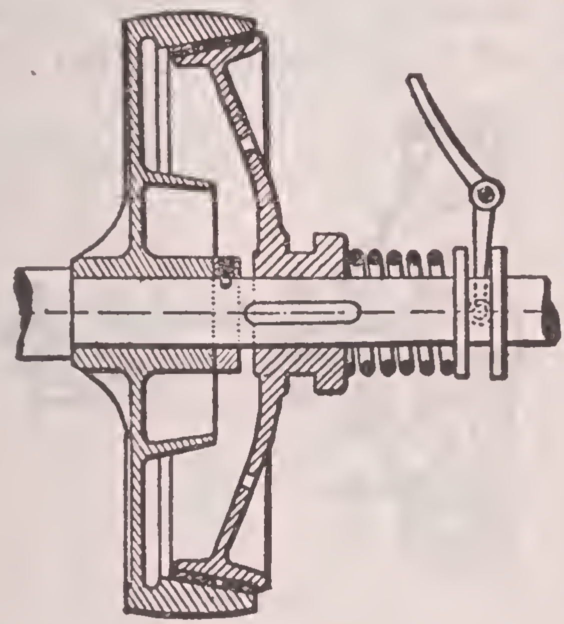


Fig. 102

away from the expansion ring. When the pedal is released, spring e forces the clutch into action again.

Fig. 102 is a sectional view of a form of leather faced cone clutch in which the male part of the cone moves axially toward the engine. Fig. 103 shows a clutch constructed on the same principle, but in place of having one strong actuating spring surrounding the axis, it has three weaker spiral springs near the periphery of the male member. Fig. 104 is a vertical section of a clutch suitable for a 50 H. P. car. The cone angle is 13 degrees, and the diameter 16 inches, with a total frictional area of 128 square inches, the axial pressure resulting from the spring being 375 lbs. A small spiral plunger spring A under the leather face B causes it to pick up the load more quietly and smoothly. Fig. 105 illustrates an early form of clutch intended for a car of about 20 H. P. One form of toggle joint is also shown at A.

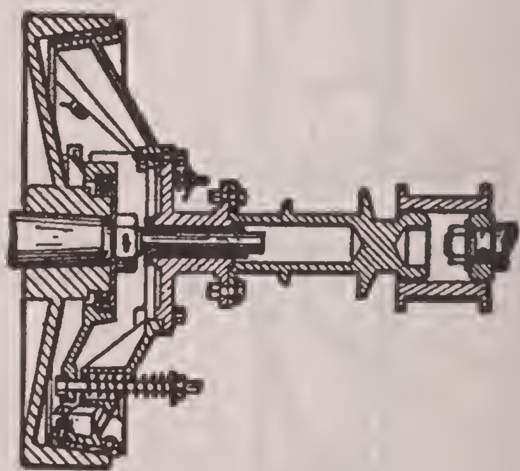


Fig. 103

This clutch also has multi-springs for creating the proper frictional contact, and a peculiar form of spring application simple in the extreme. A multi-cone clutch is shown in section in Fig. 106. Its action is as follows: When the clutch engages, the smallest cone seizes first, commences to revolve and subjects the spiral springs between the next two clutches to torsional movement, which draws them together and brings the two outer cones into action; the idea being that the small clutch shall slip, tend to accelerate the car, that the medium clutch shall behave in a similar manner and that when the large clutch comes into play the three combined pick up the load and move the car.

The so-called inverted cone is well illustrated

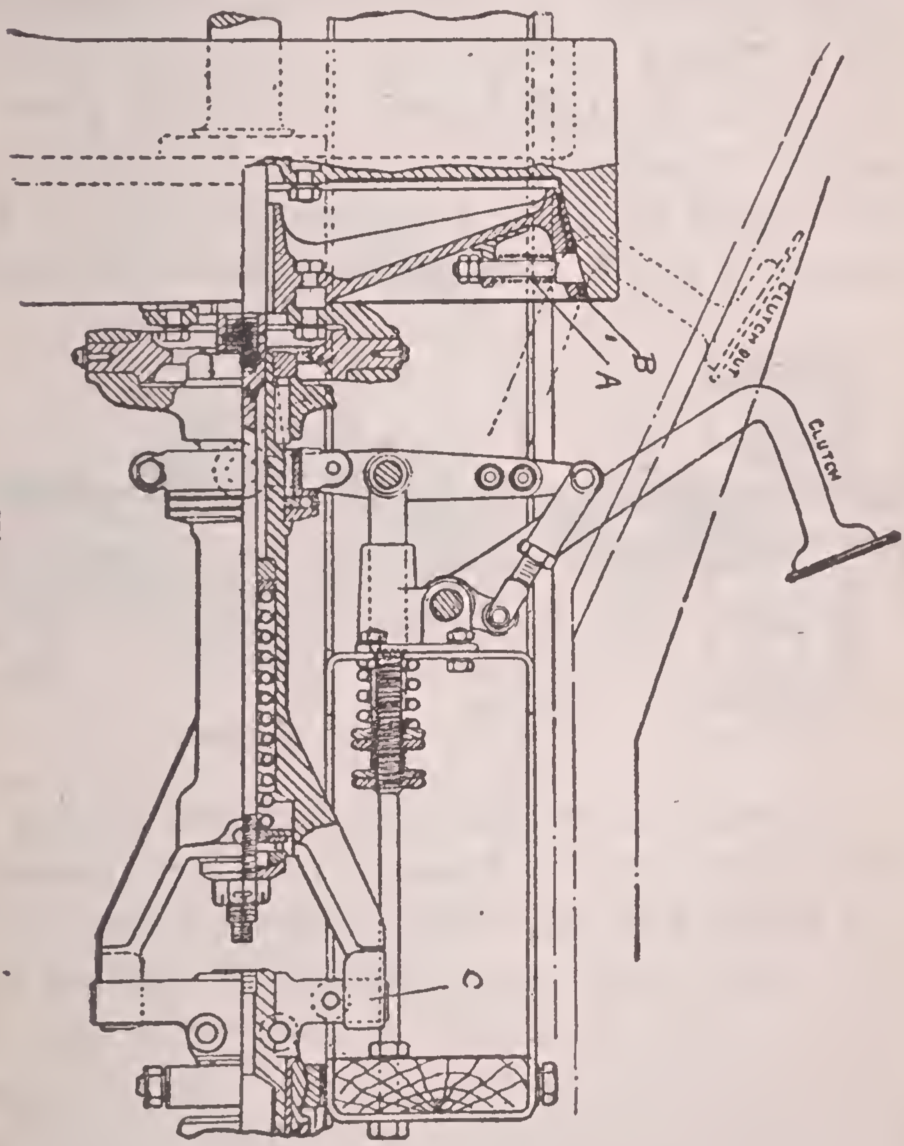


Fig. 104

in figure 107. The reversed cone is contained in an extension A, built onto the flywheel B. When the cone is disengaged it moves toward the engine, exactly reversing the action of the foregoing type. This clutch has its adherents, and it is a good one, differing very slightly, if properly assembled, in its efficiency from the direct-acting cone. It may be kept free from dirt and oil much more perfectly than in the other form.

DISK CLUTCH. A clutch of the multiple-disc type is shown in Fig. 108. A two-arm spider a, keyed to the shaft b, serves to hold in place a number of metal discs c, between which are other metal plates d held on the sleeve e by means of a key f. The sleeve e is in turn keyed

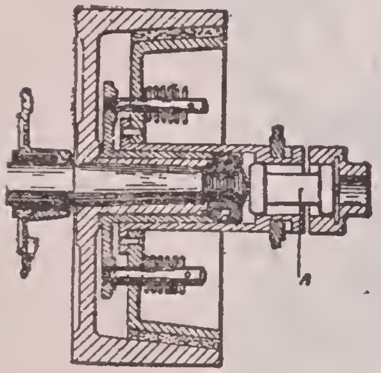


Fig. 105

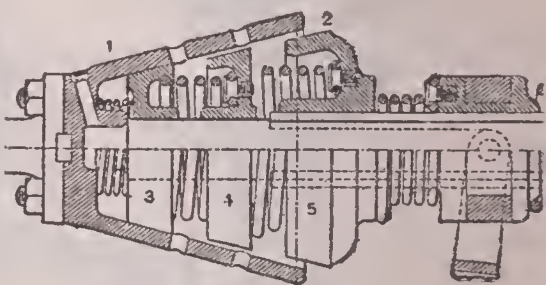


Fig. 106

to the shaft g, and to it is screwed a ring h having three pairs of lugs carrying three levers i, with rollers j at their outer ends, as shown. The other ends of the three levers press against the plate k when the clutch is engaged by an inward movement of the collar l, plate k being free to move along the key f. Discs c are free to move longitudinally on the arms of the spider a, and also on sleeve e, around which they rotate when the clutch is out of engagement; but the arms of the spider, fitting into slots in the discs, cause them to rotate with the shaft b.

The plates d are free to move longitudinally on the key f in the sleeve e; and since the sleeve is keyed to the shaft g, it is evident that, when in engagement with the discs c, the plates d must cause the shaft g to turn with the shaft b. The discs c and plates d run in an oil bath,

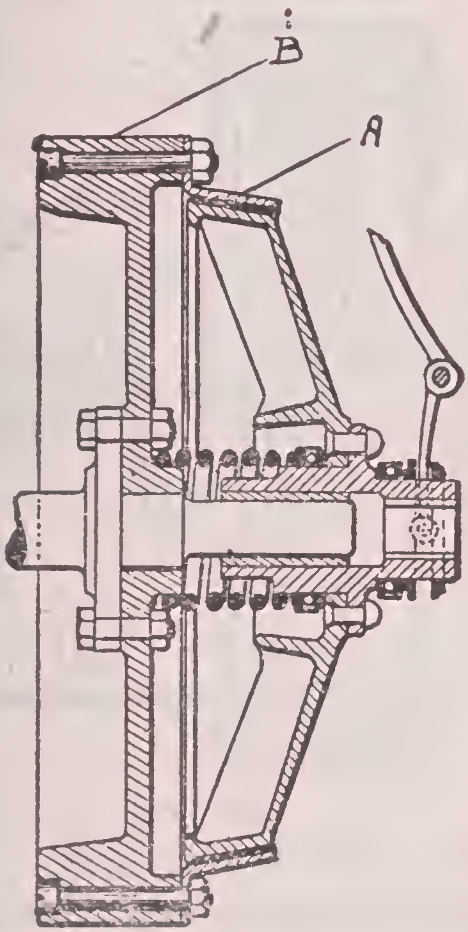


Fig. 107

obviating wear of the plates and discs. These are brought together forcibly by throwing the cone faced end of the collar l against the rollers j, thereby causing the ends of the three levers i to press the plates and discs together with sufficient force to cause the shafts b and g to rotate as one shaft.

FIVE-PLATE CLUTCH. In the matter of the number of plates in the disc clutch there is no agreement between designers. Some use a very large number of thin plates, as many as fifty or sixty, and others use a very small number, as few as six or eight; in fact, it may be said that the single disc clutch, which has only two frictional

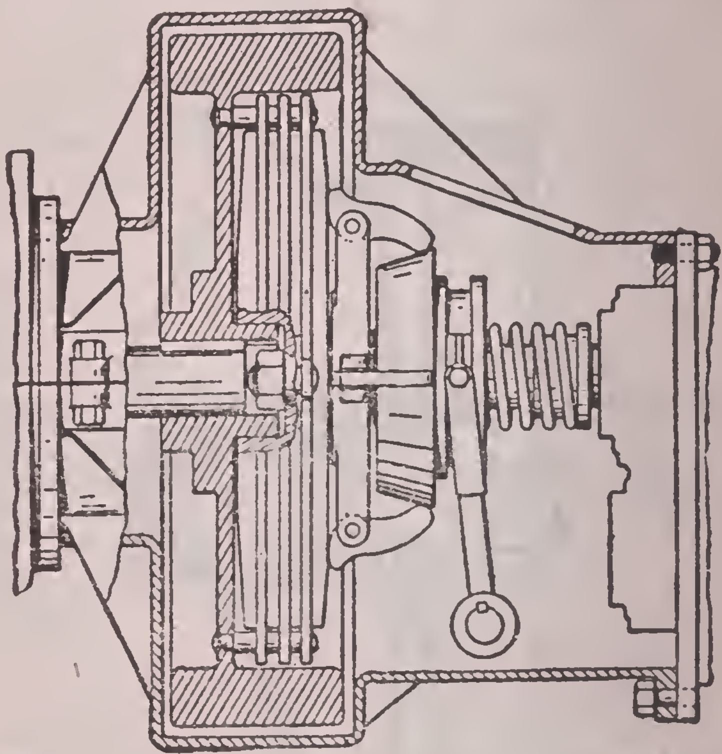


Fig. 108
Five-Plate Clutch

surfaces, is the lower limit. One arrangement which uses five plates is shown in Fig. 108. The diameter of the clutch is somewhat smaller than that of the single or three-plate types, but its diameter must be quite large in order to transmit considerable horse power.

Clutches are made with various numbers of plates, from three to more than sixty, depending on the work required and the size and material of which the plates are made. Plate materials include hardened steel for both members, steel and bronze, steel with cork inserts, and steel covered with some friction material similar to brake lining.

Disc clutches using steel to steel are operated in a bath of oil. Those using bronze and steel may or may not operate in oil. As a general rule, clutches that are not enclosed are fitted with cork or an asbestos composition as the friction material. However, either of the forms just mentioned operate satisfactorily in an oil bath, and it is, therefore, simply a question of choice with the designer. Unenclosed clutches are called "dry-plate clutches."

CLUTCH TROUBLES. One of the greatest sources of trouble for the novice lies in the clutch. This may be just right, it may be slipping, or it may be what is called fierce. The second manifests itself in such pleasant situations as climbing a hill when, with the engine running at its highest speed and the proper gear engaged, the car starts to run backward instead of forward. Or on the level, with the engine racing and the high gear in, no speed results.

The last condition shows itself in the sudden jumping forward of the car when the clutch has been let in, or it may even be so severe as to shear off the bevel driving gear when used with studded non-skid tires or any form that will not slip easily.

To repair the first, look at the leather, if this is all in good shape with an apparently good surface, but has lubricating oil on it, wash the surface well with gasoline. It is not a bad idea to roughen the surface of the leather a little with a coarse file.

The harsh or fierce clutch is remedied by the application of a proper oil for this purpose. Castor oil is universally used and a good way is to soak the complete clutch in it over night. This will cure a case of harsh leather, but it may be that the trouble is only a lack of adjustment of spring tension. Usually there is an adjusting nut and a locking nut. Back off the latter and make an adjustment. Then tighten the lock nut to retain it. For the beginner, it is better to adjust a little at a time and make several successive jobs of it than to try to do it all at once. But always adjust it as soon as possible.

The leather of the ordinary cone clutch by degrees acquires a sort of coarse surface glaze, which may or may not represent actual charring of the leather, but is certainly due to the slipping it experiences. A leather with its surface so glazed has a very harsh action, since the surface is so hard that it grips all at once. The glazed surface will not absorb oil to any appreciable extent, a fact which is easily seen on attempting to dent the surface with a thumb nail after giving the oil time to soak in. In this condition the best thing to do is to put on a new leather. Unless the angle of the cone is too abrupt, a piece of ordinary belting will serve the purpose, provided it is of uniform thickness throughout. The belting may be soaked in neatsfoot oil over night before applying, and this will render it pliable enough to take the shape of the cone. If the old leather is retained in service it becomes almost essential to squirt a little oil on it every day or two, as otherwise it may take hold with such a jerk as to endanger the transmission shafts. If the cone releases by drawing backward, there are probably openings in the web of the cone through which the spout of a squirt can may enter. Oil squirted into the flywheel interior will then quickly find its way to the clutch surface. Sooner or later, however, the leather will become glazed so smooth that it will not hold at all, and it is then liable to slip and burn up without warning. There are few things more exasperating than a clutch which cannot be made to hold properly, particularly when the car happens to be covering a bad stretch on which every available bit of power that can be transmitted to the rear wheels is necessary. The use of emergency remedies under such circumstances most often leads to the necessity for clutch repairs, as road dirt and grit are not the best things possible for the leather facing, and frequently no other friction producing compound is to be had at the time.

Renewal of Leather on Cone Clutch. Remove the old leather by cutting off the rivets on the underside, and driving the rivets through to the outside. Keep the old leather and use it as a pattern by which to cut the new piece. It will be much better, however, to purchase from the factory a new leather of the proper width and thickness. As a new leather will have considerable "give," it must be stretched tightly over the cone. First cut one end of the leather square and fasten it to the cone with two rivets. The other end should not be cut at this stage of the work, but brought around to meet the fastened end, and, after tightly stretching it over the small end of the cone, fasten it with a single rivet. Then force the leather up onto the cone, drill out and countersink the holes and rivet up securely. The only knack in the operation is to keep the leather tight that it may be a snug fit on the cone. A loose leather will, naturally, be a dead failure. After the leather has been forced into its place the uncut end should be trimmed to make a good joint. Any unevenness may be trued up with a file. The new leather will readily absorb several applications of castor oil before it becomes smooth and pliable.

Care should be taken that the rivet heads are countersunk below the surface of the leather. In case they work flush, owing to the wearing down of the leather face, they should be riveted. The "biting" or jerky action of a cone clutch may often be traced to the rivets working out, and this will frequently prevent the clutch from being readily disengaged. Reriveting will prove an effective remedy in this case, and considerable additional service may be had from the leather before it wears down to the rivet heads.

The oil used in multiple disc clutch housings should be changed at frequent intervals. The same lubricant as used in the engine is suitable for warm weather driving, while for cold weather the oil may be diluted by the addition of one-fourth to one-third kerosene to avoid dragging. The clutch housing should be filled to a point a little below the center line of the shaft.

Dry disc clutches require little care other than being kept reasonably free from dirt and accumulations of grease and oil. Their thrust release bearings should be given regular attention and kept properly lubricated with cup grease or heavy oils.

Compression. Normal compression in any given design of motor would be the compression (cold) fixed by the designer by the relation of the sweep of the piston to the clearance space. Normal compression is not the same, as measured in pounds per square inch, in all motors. The normal compression as against loss of compression would be evident to a motorist in the act of cranking. Were the compression to become abnormal, as a result of carbon deposit, it would be rendered manifest by knocking on a gradient, or by way of pre-ignition.

Compression, How to Calculate. The compression in atmospheres of a motor may be readily found by dividing the cubic contents of the piston displacement by the cubic contents of the combustion chamber in cubic inches, and then adding one to the result.

To ascertain the compression in atmospheres of a motor, when the cubic contents of the combustion chamber are known: Let S be the stroke of the piston in inches and A the area of the cylinder in square inches. If C be the contents of the combustion chamber in cubic inches and N the required compression in atmospheres, then

$$N = \frac{S \times A}{C} + 1$$

Example: Find the compression in atmospheres of a motor of 4-inch bore and 6-inch stroke, whose combustion chamber has a capacity of 18 cubic inches.

Answer: Six multiplied by 12.56 equals 75.36, which divided by 18 gives 4.19, and 4.19 plus 1 equals 5.19, or the compression in atmospheres required. One atmosphere = 14.75.

If it is desired to ascertain the compression in atmospheres of a motor, the combustion chamber of which is of such shape that its dimensions cannot be accurately calculated, its cubic contents may be found by filling the combustion chamber with water, and after removing the water, ascertaining its weight in ounces, and then multiplying the result by 1.72. This gives the capacity of the combustion chamber in cubic inches. The compression of the motor can then be readily calculated from the formula given herewith.

Compression, How to Test for Leaks in. To discover if there are any leaks in the compression of a gasoline motor, a small pressure gauge reading up to 75 pounds should be fitted into the spark plug opening in the combustion chamber by means of a reducing bushing. When turning the starting crank of the motor slowly the gauge should indicate at least 60 pounds per square inch if the compression is in good condition.

To test for leaks, fill a small oil can with soapy water and squirt round every joint where there may be a possible chance for leakage. Get an assistant to turn the crank and watch for bubbles at the joints.

If the joints are all tight, next examine the condition of the admission and exhaust-valves and if either of them needs regrinding, it should be done, first with fine emery powder and oil, then finished with tripoli and water.

When the valves have been ground to a perfect fit, if the compression still leaks, the piston rings should be examined, as the trouble will be found to be with them.

Condenser, Use of. A condenser is used in connection with a Rumkorff, or jump-spark form of induction coil to take up or absorb the static charge of electricity, occasioned by the self-induction, or electrical reaction in the primary winding of the coil upon the breaking of the battery circuit by the interrupter or vibrator. This static charge is given up or dis-

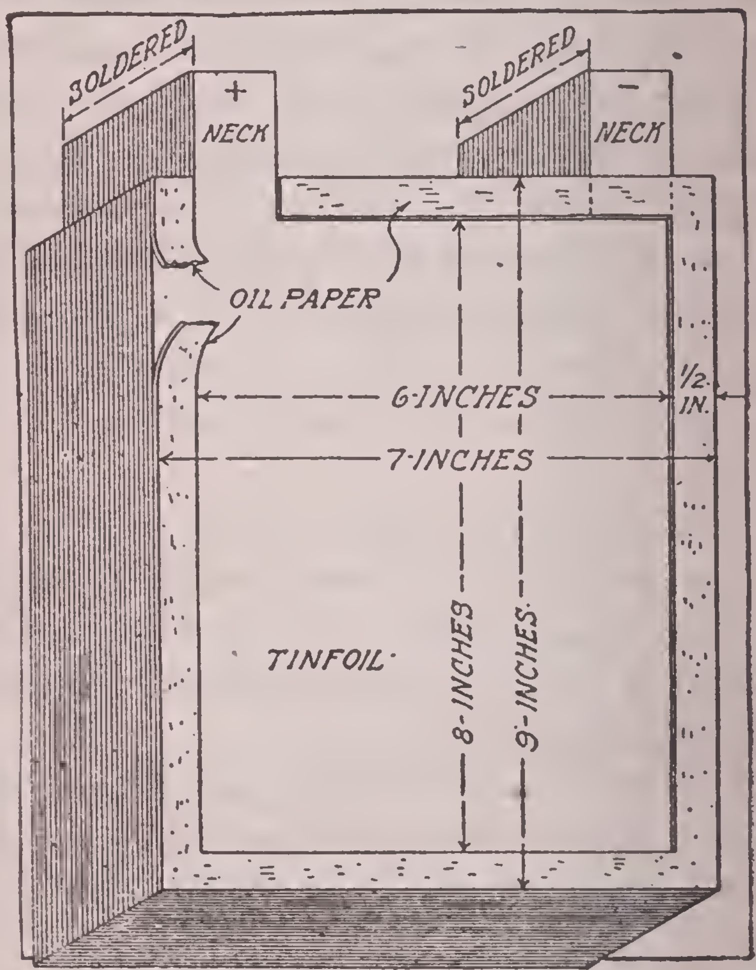


Fig. 109
Condenser

charged into the primary winding of the coil along with the battery current upon the closing of the circuit, thus intensifying the action of the secondary winding of the coil in a great degree.

By absorbing the static charge of electricity the condenser helps to decrease the spark or arc between the platinum contact points of the interrupter or vibrator, thereby lengthening the life of the platinum contacts by reducing the erosive action of the induced current spark. A jump-spark coil very often refuses to work properly on account of the condenser connections having become loose.

The capacity of a condenser is directly proportional to the area of the tinfoil sheets composing it, to the distance between the sheets, and to the inductive capacity of the dielectric, or separating medium.

In condenser work it is the custom to cut the tin-foil sheets to some convenient rectangular shape, as shown in Fig. 112, each one with a neck so that all the + sheets can be soldered together, on one side, and all the — sheets on the other. The dielectric paper is cut without necks, so that the necks of the tin-foil sheets can be readily contacted with each other, in such a way, however, that the + sheets will not contact with the — sheets at any point. The paper is 1 inch wider than the tin-foil, so that the paper extends out for ½ inch all around, and beyond the tin-foil. In the illustration the top sheet of paper is removed to show the shape of the tin-foil sheets, and it will be observed that all the tin-foil sheets are of the same size, but they are so turned that the + sheets have their necks all to one side, while the — sheets have all their necks to the other side. Any number of sheets can be used, with the understanding that a sheet of oil-paper will be placed between adjacent tin-foil sheets, so that the + and — sheets will not contact with each other at any point.

If the paper is pierced, or if the + and — tin-foil sheets contact with each other, the condenser will fail to perform its functions, and it sometimes happens that the sheets are punctured in service, thus rendering the condenser valueless for the intended purpose until the puncture is repaired, to do which requires that the fault be found, and a new sheet of paper substituted.

Condensers are made to fit into housings that allow of ready application on the instrument with which they are used. In many cases it is desirable to use a cylindrical form, while in others a rectangular outline may be permissible. Condensers of unusual form are often made from two long strips of tin foil, laid one upon the other, and separated by waxed paper or other insulating material. The long strip is then rolled or folded into the shape that is desired and the ends of the foil are attached to the condenser terminals.

A punctured or faulty condenser will cause the spark to be very weak and will also cause quite violent arcing at the breaker contacts, this arcing burning and pitting the contacts until they can no longer carry the current. The condenser connections must always be secure.

Conductivity and Resistance. The following table shows the relative ability of various metals to conduct electricity and heat:

	Heat	Electricity
Silver	100	100
Copper	74	99
Aluminum	38	63
Brass	23	22
Zinc	19	29
Tin	14	15
Wrought Iron	12	16
Steel	11.5	12
Cast Iron	11	12
Bronze	9	7
Lead	8	9

It will be seen that, in general, the conductivity of a metal for either heat or electricity is in about the same relative proportion; that is, a good conductor of one is usually a good conductor of the other.

A list of commonly used insulators with their relative ability to withstand electrical pressure is given below:

Rubber, hard	100	Wax	46
Paper, oiled	100	Paraffin	46
Mica	92	Rosin	40
Cloth, oiled	80	Glass	32
Rubber, india	72	Linen	26
Celluloid	64	Lava	24
Porcelain	48	Paper	20

Cooling Systems. The cooling of a gasoline or other automobile engine may seem a simple thing to the uninitiated, but in reality it is far from that and it is a fact that the deeper one goes into it, the more complex the situation becomes.

The cooling of internal combustion engines, in which category automobile engines come, is divided into two classes, viz., air cooled and liquid cooled. There are two reasons for cooling the cylinder walls. One is to permit of proper lubrication, and the other is to prevent pre-ignition. But it is advisable to allow the cylinder to work at as high a temperature as the lubricating oil will stand without carbonizing. The nearer the cylinder temperature can be kept to 350 degrees the more efficient will the motor be, speaking from the thermal standpoint, while on the other hand, mechanical efficiency may be sacrificed by too high temperatures. Therefore, a balance between the two should be established, and this course is usually pursued in practice.

Air-Cooled Automobile Engines. The successful air cooling of an engine cylinder depends chiefly on an abundant flow of cool air over it. Some cylinders, however, are arranged to utilize a more rapid flow than others. Generally speaking, the designer can take his choice between a comparatively plain cylinder surface over which a current of air can flow almost unchecked, and a cylinder with its heat-radiating surface greatly multiplied by numerous pins, deep ribs, or other projections. These projections increase greatly the radiating surface, but tend to obstruct the flow of air, although they aid in carrying away the heat. In the latter case, the velocity of the air stream does not need to be high, provided it is continuous; while in the former case, a constant and abundant supply of air is essential.

AIR-COOLING SYSTEMS. In modern automobile practice two systems of cooling are used—the air system and the water system, each of which has its adherents. As its name indicates, the air cooling system allows the air to strike the exterior of the engine cylinder, and thus carry off the excess of heat generated within it. To give the radiating surface, required for air cooling, the exteriors of the cylinders are either grooved or corrugated, or the surface of the cylinder is studded with metal pins or fins, so as to present as much surface to the outside air as possible. The object in the construction of all air-cooled motors is to make their external surfaces offer as great a surface to the air as possible, and to furnish these surfaces with as large a supply as possible. A fan is therefore used, driven by the engine itself, which constantly directs a current of fresh, unheated air upon the surface of the cylinder.

The Franklin principle of air cooling is shown in Figure 110 and the details of the engine and air jacket construction are shown in Figure 111.

The engine cylinders are fitted with vertical ribs and outside of these ribs is placed a sheet metal jacket. Air is taken in through the top of the jacket and passes down along the outside of the cylinders between the ribs, issuing from the bottom.

Cool air enters through the front of the engine hood and passes to a compartment above the cylinders, this upper compartment being separated from the lower space by a sheet metal plate which fits tightly between the hood and

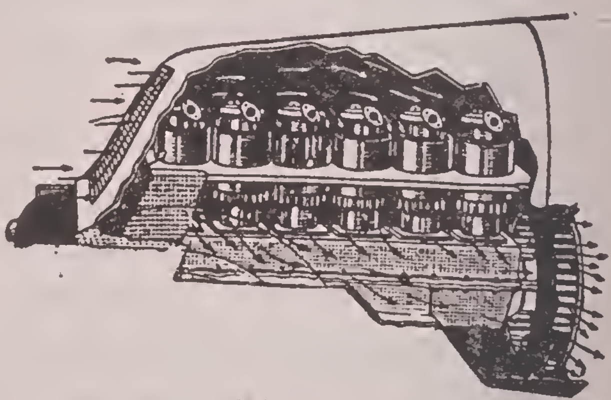


Fig. 110
Franklin Air Cooling

the jackets around the several cylinders. The only outlet for the air is then through the spaces around the engine cylinders, by means of which it passes to the lower compartment under the hood.

From the lower compartment the air is exhausted by means of a turbine type of fan built as a part of the engine flywheel. Exhaustion of the heated air results in a continual flow through the cooling system at the rate of about

2200 cubic feet per minute at ordinary car speeds.

It will be noted that none of the heated air from one cylinder touches any other cylinder, the total volume of entering air being divided

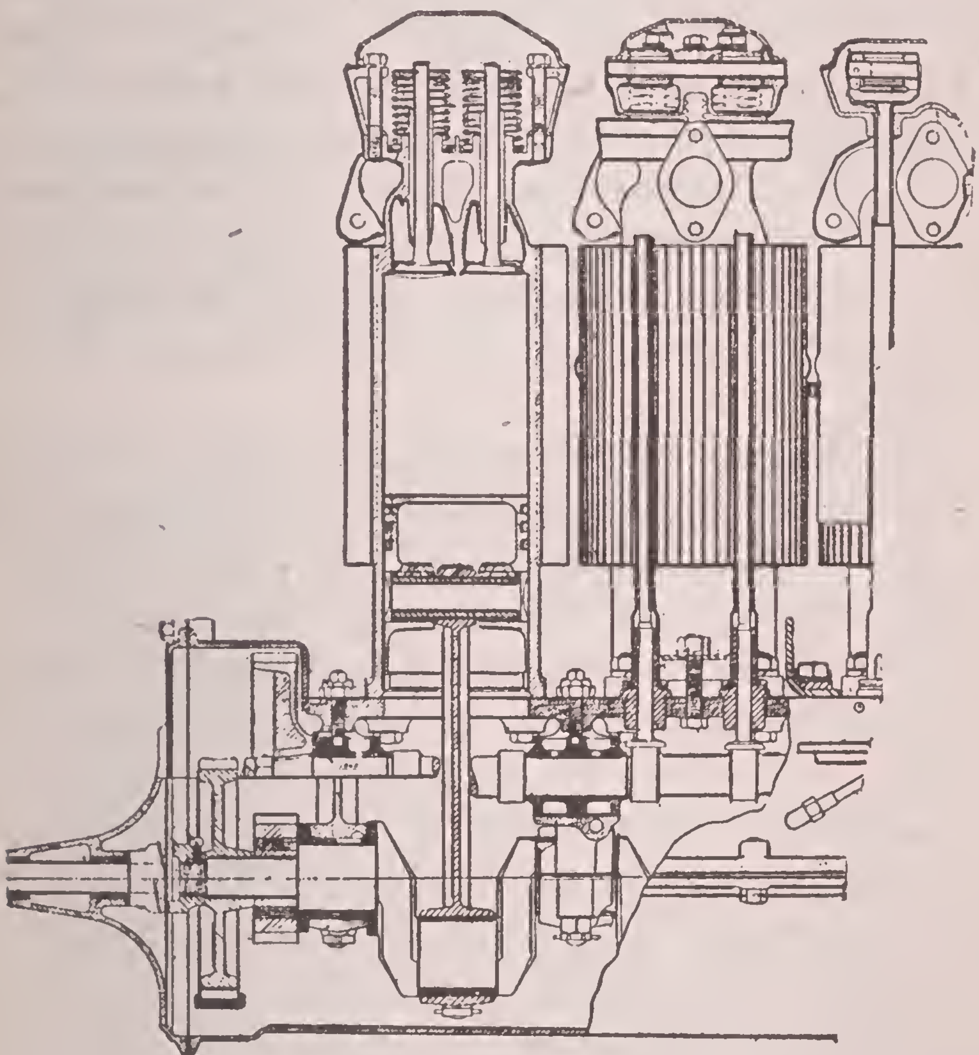


Fig. 111
Franklin Cylinder Jackets

between the whole number of jackets in a fairly even flow. This system of cooling has been used on the Franklin car for a number of years and gives excellent results.

Cooling, Water System of. The water cooling system includes the jackets around the upper parts of the cylinders and valve pockets, a radiator by means of which the heated water is cooled with a flow of air, a fan for maintaining the required air stream, a means for causing a circulation of water through the parts, either a pump or a natural thermo-syphon action, and the piping required to complete the water circuit.

WATER CIRCULATION. There are two systems of water circulation in use for cooling the cylinders of explosive motors: The natural or thermo-siphon system and the forced water circulation.

In natural or thermo-siphon water circulation the fact that cold water is heavier than hot water is taken advantage of. A head of water is obtained by placing the tank above the level of the cylinder water-jacket, and as the water in the jacket is heated by the combustion, the cooler water from the tank flows in, forcing the heated water in the tank to take its place, and in this manner an automatic circulation of water is set up. The pipes must be so arranged that they offer every facility for the free circulation of the water, the cold water leaving through a pipe at the bottom of the tank and entering at the lowest point of the cylinder, while the hot water leaves the top of the cylinder and enters the tank at the side near the top. The water circulation, though automatic, is very slow, and for this reason requires a

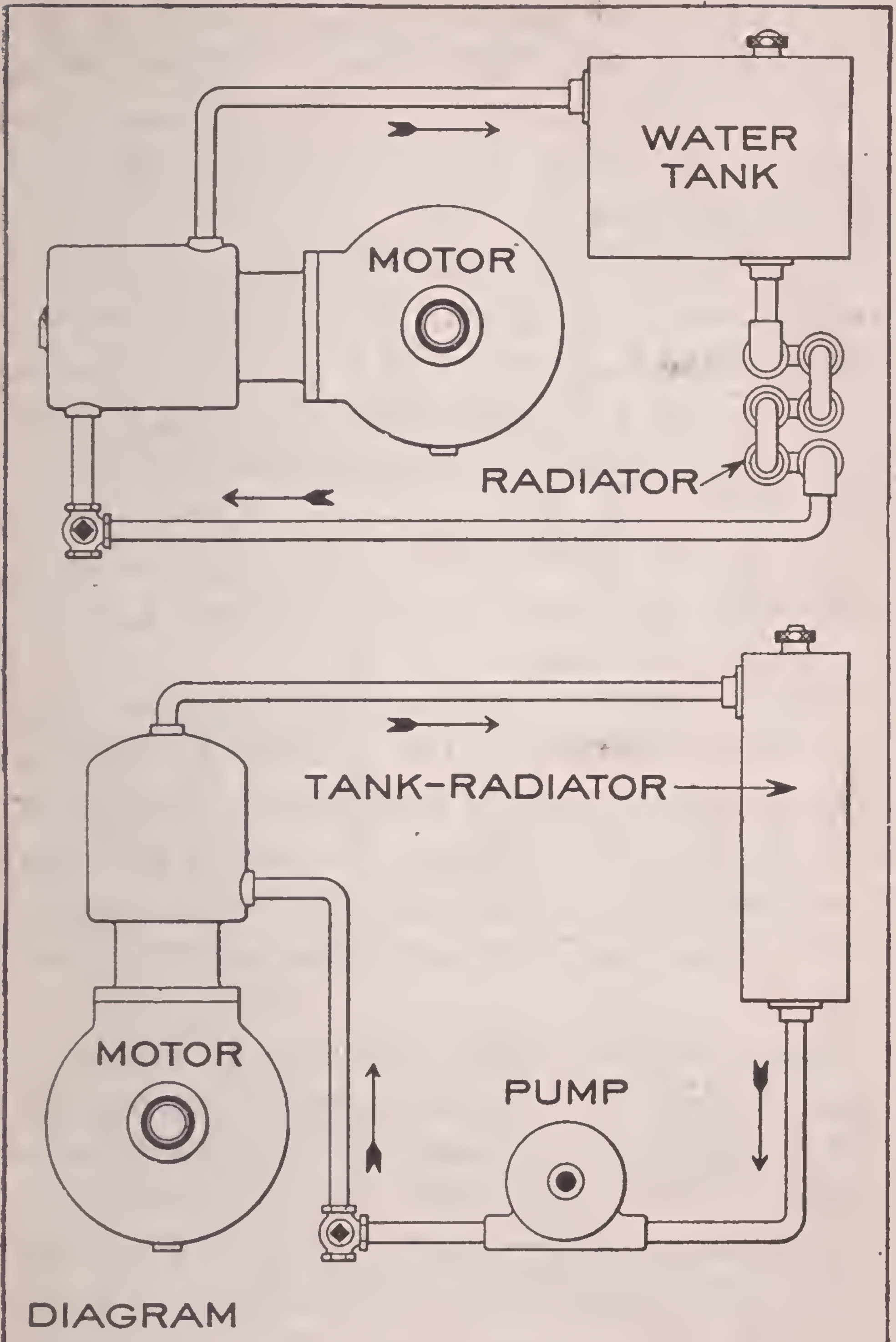


Fig. 112

larger body of water to produce as good a cooling effect as a forced circulation.

In forced circulation a rotary pump is used, the direction of the flow being such that the water passes from the pump to the cylinder, thence to the radiator, on to the tank, and then through the pump again, thus completing its circuit. The water in this way gets the maximum cooling effect from the radiator, and the body of water in the tank is kept cool. On account of the high speed of a gasoline automobile motor, and the comparatively small amount of power required to circulate the water, rotary pumps are much used. As there are no valves to get out of order, and high speed is obtainable, this type of pump is very suitable for automobile use.

In order that a thermo-syphon system may operate successfully, it is absolutely essential that the water passages around the cylinders, as well as the connections to the radiator, be of large capacity and perfectly free from obstructions. Sharp bends should be avoided in every case.

Pump, Water. The circulating pump is used in the belief that it affords a means for regulating the temperature of the jacket water supply, which would not always be the case with a thermal-syphon system. Such is not the case, as the pump, being driven direct from the motor, operates at a speed which varies with the motor speed. On starting the motor, it pumps cold water into the jacket. It pumps slowly at slow speeds, although the motor may be taking a full charge and heating rapidly. It pumps fast at high speeds, although the wind pressure and its consequent cooling effect may

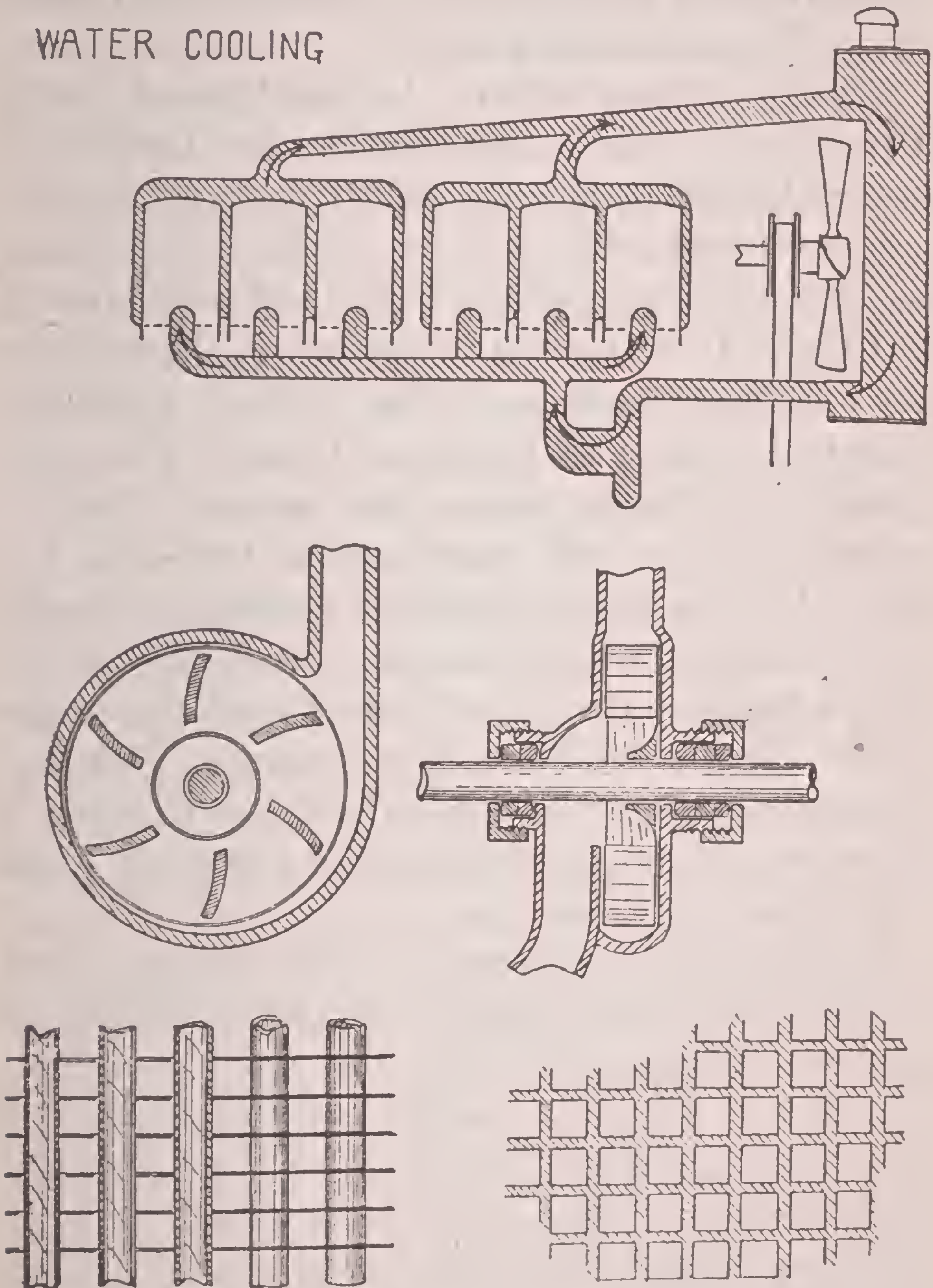


Fig. 113
Top: Water Circulation
Center: Centrifugal Pump
Bottom, left: Tubular Radiator
Bottom, right: Cellular Radiator

be very great. If a circulating pump could be used in connection with a device to control the regulation of the motor temperature, the results would be more satisfactory.

Pumps—Centrifugal. In this type of pump the height of lift is governed by the tangential force. Owing to this fact centrifugal pumps for use on automobiles may be made of aluminum for the housing, as it is both light and strong, fully able to withstand the pressure, there being no rubbing surfaces. The wheel, however, should be made of phosphor bronze of a good grade. In these pumps the suction inlet is usually at one side surrounding the axis, see Fig. 113. The pump should be geared to a speed as high if not higher than the crankshaft speed. The minimum peripheral velocity of the pump wheel should be 500 feet per minute. For automobile service the general rule is to have a three vane wheel, and the curving is away from the direction of rotation.

Overheating—Causes of. Overheating of the engine, when not traced to poor circulation, is almost always caused by too much gasoline. There are, however, many possible causes of over rich mixture, some of which on the face of them might seem to be causes of lean mixture rather than rich. Prominent among these latter is too low a gasoline level in the float chamber due to the float valve closing too soon. The immediate effect of this is to make the mixture too lean at starting, and at low speeds. Starting is therefore difficult, and if the auxiliary air valve begins to open at the usual motor speed, the mixture will again be much too lean. These symptoms, however, unless properly interpreted will probably lead the owner to increase the gasoline supply, or to adjust the spring tension of the auxiliary valve so that the latter will not open until quite high speed is attained. In other words, he adjusts to give a suitable mixture at one speed, and at other speeds the mixture is extravagantly over rich. It is well not to be too easily satisfied with the carbureter's performance, as it may be found that one fault such as the above has been imperfectly offset by another fault in the other direction instead of the correct adjustment being made where the fault really lies. A good carbureter will give a sensibly correct mixture at all speeds within the ordinary range of the engine. If it fails to do this the thing to do is to investigate until the trouble is found.

Insufficient lubrication increases the friction between the piston and cylinder, and so generates extra heat. Bad or unsuitable oil may have the same effect.

Wear of the cams, tappets and valve stems may be the cause of overheating, as it would not require much loss from the faces of the various moving parts that come in contact to cause a more or less appreciable difference in the operation of the valves, and as this wear tends to bring about a later action, it may be sufficient in the case of the exhaust valve to retain the burnt charge considerably beyond the time at which it should be allowed to escape. Where a motor runs at a speed of 800 revolutions per minute or over, it will be evident that it is a matter of very small fractions of a second.

Another cause of overheating may be the deposit of a fine film of scale on the inside of the circulating pipes and radiator. This scale is of a mineral nature, and, in addition to being an excellent nonconductor of heat, it is deposited in such intimate contact with the metal that the latter is practically insulated and its radiating power entirely lost.

OVERHEATING—EFFECTS OF. The immediate effect of overheating is to burn up the oil in the cylinders, or crank case. This causes a smell of burning, and an ordor of hot metal. There is sometimes a slight smoke and the motor will make a knocking sound. The cooling water begins to steam, and the car will gradually slow down and finally stop.

The most serious cause of a stoppage on the road is overheating, which causes the lubricating oil to burn up and the piston to expand and grip or seize in the cylinder.

OVERHEATING—REMEDIES FOR. As soon as any of the above symptoms are noticed:

The motor should be stopped at once.

Kerosene should be copiously injected into the cylinders and the motor turned by hand to free the piston-rings.

The parts should then be allowed to cool.

Do not pour cold water on the cylinder jackets, for fear of cracking them, but pour the water into the tank so as to warm the water before it reaches the cylinder jackets.

A simple test in the case of an overheated motor is to let a few drops of water fall on the head of the cylinder. If it sizzles for a few moments the overheating is not bad, but if the water at once turns into steam, the case is serious.

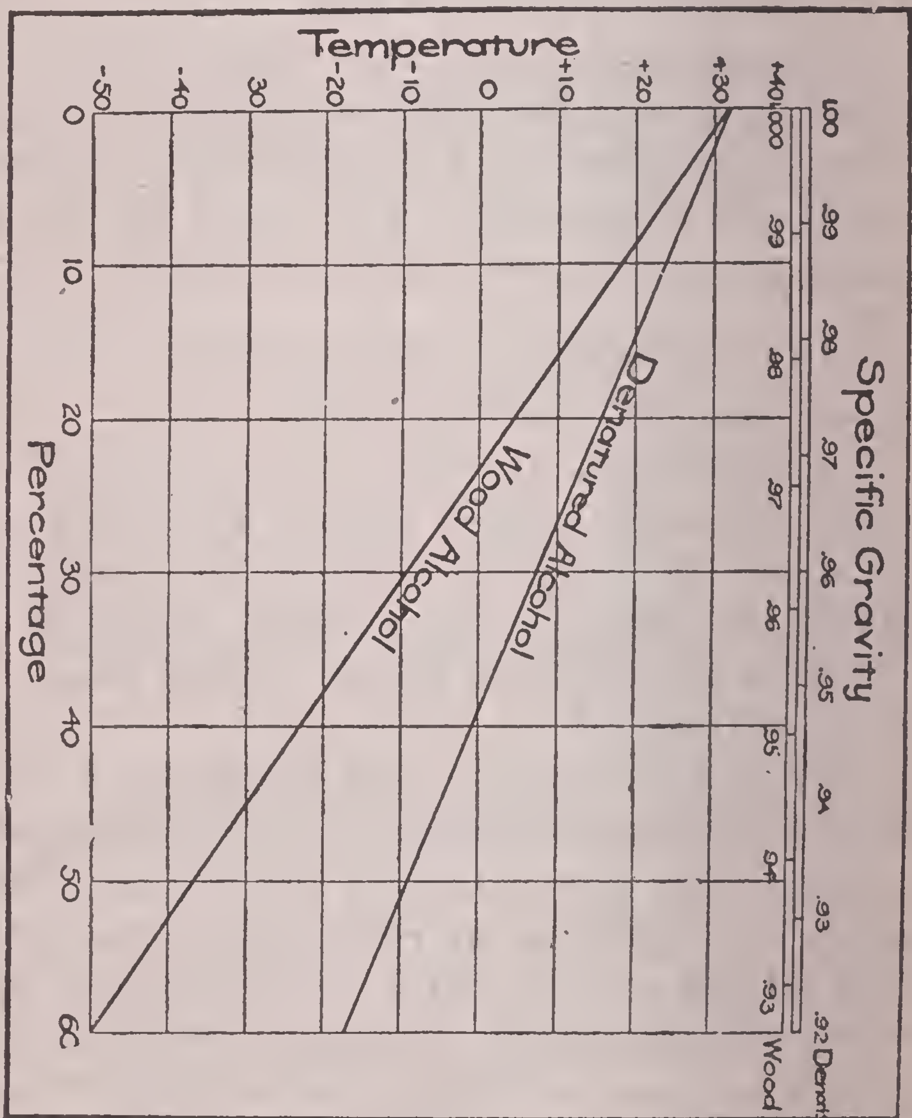
After the parts are cool, it will be advisable to put some oil in each cylinder.

ANTI-FREEZING MIXTURES. If a solution of alcohol and water is used, the best results will be obtained by having it just strong enough to stand the lowest temperature to which it is likely to be subjected in the climate where it is to be used.

The reason for this is that the alcohol evaporates out from the solution, and the stronger the solution, the more there is to evaporate, the easier it evaporates, and the greater the influence of this evaporation upon the solution left.

The diagram shown on page 33 indicates the freezing points of various solutions of denatured alcohol, also of wood alcohol. From this diagram a solution may be selected which will stand any temperature from 50° below zero to 40° above.

Other solutions may be made with calcium chloride (common salt), also the salts known as potassium carbonate. These with water form a solution that will stand zero temperatures, but are not available where lower temperatures are common.



NON-FREEZING MIXTURES FOR RADIATORS. In cold weather, the circulating water, the oil, and the carbureter require special attention. If the car is to be run regularly during the winter, it is advisable to use a non-freezing mixture in the water-jacket. If the car is not to be used regularly, it may not be necessary to employ such a mixture, but in that case great care is necessary to prevent the water from freezing unexpectedly. If the car is kept in a barn, the water should be drawn off completely after the car has been used, and the drainage cock should be so located and the piping so arranged that there are no water pockets in which the water may freeze and obstruct the circulation. If the water freezes in the pump, the latter is likely to be broken when the car is started the next morning. If water freezes in the water-jackets, it will burst the jackets unless they are made of copper. When the car is left standing for an hour or so, cloths

---

PROPORTIONS OF GLYCERINE, ALCOHOL AND WATER.

Freezing Point	Glycerine and Alcohol (equal parts)	Water
28° above	15%	85%
15° above	20%	80%
10° above	24%	76%
5° above	28%	72%
Zero	30%	70%
5° below	33%	67%
10° below	36%	64%

or lap robes may be thrown over the radiator to check the cooling; this is cheaper and safer than leaving the motor running.

The two substances most used to prevent freezing are glycerine and calcium chloride. A 30-per-cent solution of glycerine in water freezes at 21° F.; and a solution of one part of glycerine to two parts of water is safe from freezing at 10° or 15° F.; 40-per-cent solution freezes at zero. A small amount of slaked lime should be added to neutralize any acidity in the solution. Glycerine has the objection that it destroys rubber, and the solution fouls rather quickly.

A cheaper mixture, and one preferable where the temperatures encountered are likely to be below 15° or 20° F., is a solution of calcium chloride. This must be carefully distinguished from chloride of lime (bleaching powder), which is injurious to metal surfaces. Calcium chloride costs about 8 cents a pound in bulk, and does not materially affect metals except zinc. A saturated solution is first made by adding about 15 pounds of the chloride to 1 gallon of water, making a total of about 2 gallons. Some undissolved crystals should remain at the bottom as evidence that the solution is saturated. To this solution is added from 2 to 3 gallons of water, the former making what is called a 50-per-cent. solution. A little lime is added to neutralize acidity. A 50-per-cent solution freezes at —15° F.

Whether glycerine or calcium chloride is used, loss by evaporation should be made up by adding pure water, and loss through leakage by adding fresh solution. In using the chloride, it is important to prevent the solution from approaching the point of saturation, as the chloride will then crystallize out and clog the radiator, besides boiling, and failing to cool the motor. A 50-per-cent. solution has a specific gravity of 1.21, and should be tested occasionally by means of a storage-battery hydrometer. Equally important is it to prevent the water from approaching the boiling point, whatever the density, as boiling liberates free hydrochloric acid, which at once attacks the metal of the radiator and cylinders.

A solution of two parts of glycerine, one part of water, and one part of wood alcohol has been recommended, which is said to withstand about zero temperature.

Certain mineral oils used for the lubrication of refrigerating machinery are recommended for cooling, because they remain liquid at very low temperatures. They are not particularly good heat conductors, however, and will not keep the motor as cool as the water solution. If the oil is used, it must be cleaned from the radiator by the use of kerosene and oil soap, before water can again be used effectively.

As regards lubrication, the principal danger is that the oil will thicken from the cold so that it will refuse to feed. This is avoided by using cold test oil, which remains liquid at lower temperatures than ordinary oil, or by adding to the ordinary oil some kerosene or gasoline, and increasing the feed. If the oil tank is located close to the engine, it will remain liquid, even in quite cold weather. But unless the car has been kept in a warm place over night, the bearings are liable to run dry before the car has warmed up.

Cooling Solutions—For Winter. Radiators are costly, delicate and composite in construction, the latter due to the plurality of metals in their make-up, hence electrolytic action takes place, due to the difference of potential natural to the different metals immersed in a saline bath. Therefore great care should be exercised in the preparation of anti-freezing solutions made up of calcium chloride (common salt and water). Any approach to the saturation limit is attended with danger of precipitation. The saturated solution is ascertained at 60 degrees F., and increasing the temperature increases the capacity of the water to hold the salts in suspension.

On the other hand, the Ohmic resistance of a solution is lowest at about half saturation. To sum up, it is experience that counts, and it is still a question as to the extent to which saline solutions can be used with safety. Of course there is no solution as good as water alone, but unfortunately water will expand when it freezes, and it will freeze on small provocation in a radiator. Oil as a cooling medium has points in its favor which some authorities claim render it more efficient than water, as for instance it has a higher boiling point, about double that of water, and as a result the oil will not waste away except by leakage. The heat exchange occurs at a higher temperature, thereby increasing the efficiency of the motor. Then also the area of radiating surface may be smaller, with a conesquent decrease in weight, while the work of the fan is rendered of less importance. A light, thin, pure mineral oil is the most reliable. Animal, and vegetable oils are more apt to become rancid, the acid in them also attacks the metal of the radiator.

Deposits in Water Jacket. If the cooling water contains lime or alkali, the heating of the water in the jacket will cause these solid substances to be deposited in the cooling spaces. This will soon choke any narrow ports and prevent proper circulation, resulting in overheating, rapid wearing of the valves, and loss of power and efficiency. A simple remedy consists of the application, at regular intervals, of a dilute solution of hydrochloric, or muriatic, acid, made as follows: Dilute one part of muriatic acid with nineteen parts of water, and, after draining the jacket completely, pour in enough of the solution to fill the entire cooling space. Allow the mixture to remain in the jacket for not more than 8 to 12 hours, after which wash the cooling space thoroughly by running clear water through it. If the solution is permitted to remain in the jacket longer than the period stated, there is danger that the metal may be damaged by the action of the acid. The acid will soften and dissolve the lime or alkali, and the clean water will remove it from the jacket. It is generally sufficient to apply this method of removing the deposits once every two weeks. If neglected too long, the acid will not dissolve the deposit.

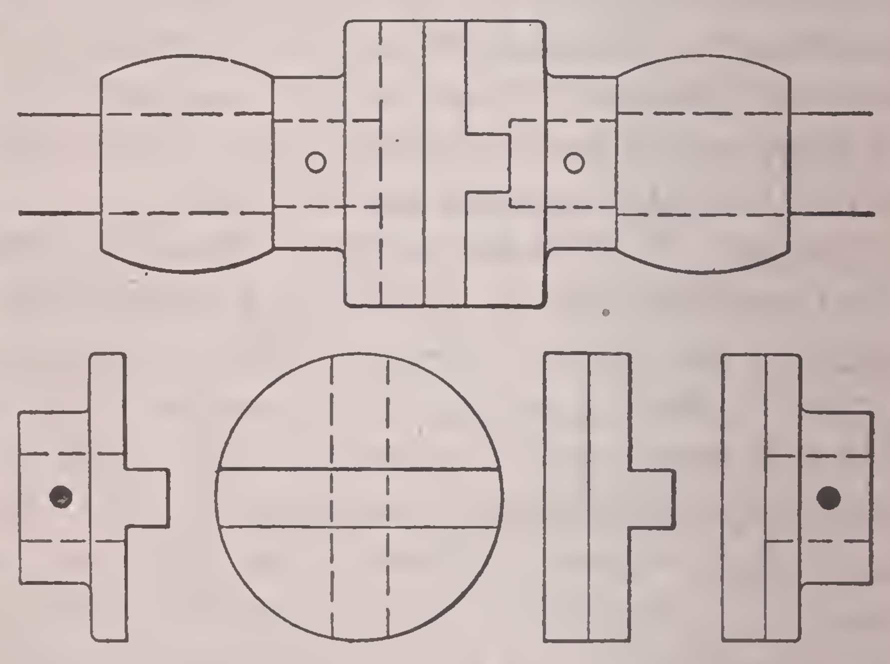

COMPENSATING DEVICE

Fig. 114

Coupling, Oldham. On account of the distortion of the frame or running gear of an automobile, due to unequal spring deflection and irregularities of the road surface, means should be provided to insure flexible joints or connections between the various rotating parts of the mechanism of a car. The device shown in Figure 114 is not susceptible to any great amount of angular distortion, but will transmit power with a practically uniform velocity, with the axes of the shafts considerably out of alignment in vertical or horizontal parallel planes.

Differential Gears. So long as an automobile moves in a perfectly straight path, its two driving wheels turn at equal speed, since they must cover equal distances in equal periods of time, and it would be perfectly allowable that the two wheels should be locked together, as there would be no relative motion between them. The power could be transmitted to either one, or to both of them with perfectly satisfactory results under these circumstances. When, however, a car is to be moved in a curved path, as in turning a corner, the driving wheels must move at different speeds, since the outside one has to cover a longer distance in the same time than does the wheel which is on the inside of the curve. If the two wheels were locked together under these conditions, one or both of them would be forced to slip, as the speeds transmitted to them would be equal, while the distances they are to travel are unequal. This difficulty is successfully overcome by the use of the differential gear which transmits the power from the change-speed gear to the rear axle, or driving wheels of the car. Differential gears consist of a set of four or more gears attached to the ends of two shafts that meet, and are usually in line, so that both are rotated in the same direction. But, if either meets with extra resistance it may rotate more slowly than the other, or may stop altogether.

These gears are used on the driving axles of automobiles. The axle is made in two parts, with a gear on the end of each, where the parts come together. Other gears mesh with both these axle gears, and are driven from the engine by a sprocket and chain, or by bevel gears and shaft. These gears turn the axle, but permit

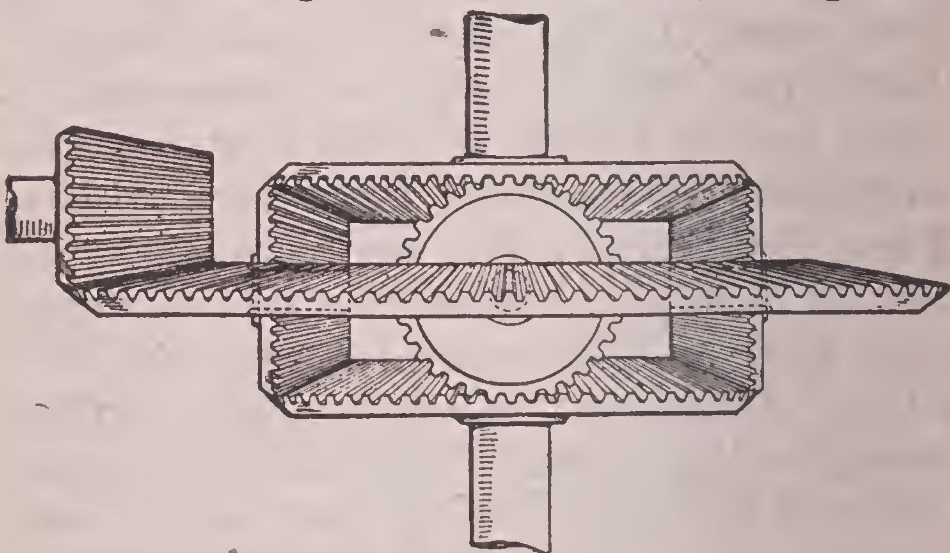


Fig. 115
Bevel Gear Differential With Bevel Driving Gear and Pinion

its two parts to turn in respect to each other so as to allow the automobile to go around a corner without causing the wheels to slide, or skid. The rear wheels are each fixed to a half of the rear axle, and both receive power, hence it is necessary to allow one wheel to turn at a different speed from the other, and this is accomplished by means of the differential gear.

Bevel Gear Differential. Fig. 117 shows a bevel gear differential in which A and B are the two halves of the rear axle, which is divided at its center. One of the driving wheels is carried on A, and the other one on B, while the inner ends of the two half axles are each fitted with bevel gear wheels C and D. Meshing with these two bevel gears are two, three or four bevel gears, two of which are shown at E and F. These pinions are supported on radial studs which project inwardly from the casing. Upon this casing are sprocket or bevel gear teeth which are driven from the engine. The teeth of each pinion, E and F are at all times in mesh with the teeth of both the bevel gears C and D on the axle. When the car is in operation, the chain or bevel drive revolves the case containing the pinions, and the power is transmitted through the teeth of the pinions E and F to the teeth of the gears C and D and thence to the axle and wheels. So long as the vehicle travels in a straight line, the pinions act as stationary driving members, and have no occasion to revolve, as the two halves of the axle and their gears are moving at equal speeds. They merely revolve with the frame. The same teeth of the bevel pinions and gears are in contact so long as a straight path is traversed. When, however, the car is steered in a curve and different velocities are required in the drivers and the bevel gears with which they are connected, the pinions no longer act as fixed driving members, but each turns upon its stud and allows the necessary relative motion between the two bevel gears, and at the same time they continually transmit power to the two ends of the axle because they are always in mesh with each other. This compensating action may continue indefinitely through any amount of variation between the driving wheel rotation, because one

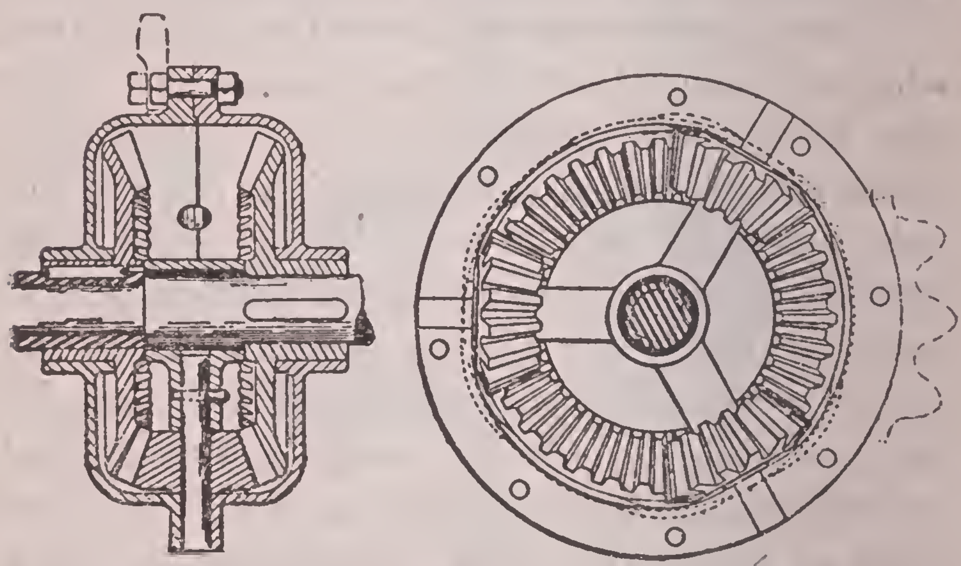


Fig. 116
Bevel Gear Differential Connected to Sprocket

tooth of the pinions comes into play as fast as the preceding one disengages with the bevel wheels on the shaft. Fig. 116 presents a larger view of the bevel gear differential, the two gears on the rear axle being shown as secured to the shaft, and to a sleeve on the shaft. The differential employed here has three bevel pinions turning on radial studs, which are secured to the arms of a spider at their inner end. A differential bevel gear, although most extensively used, is open to the objection that the bevel gears impose an end thrust upon the two halves of the mainshaft on rear axle. This has led to the design of differentials in which only spur gears are used.

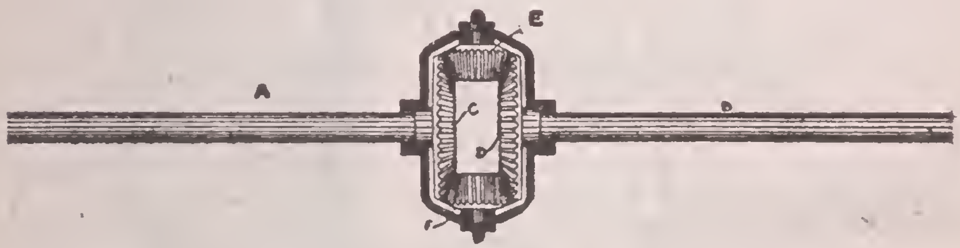


Fig. 117.
Bevel Gear Differential.

Bevel Gear Differential. Fig. 118 shows a semi-sectional view of the bevel differential gear. The engine shaft carries a bevel gear wheel shown in section at a. This gear meshes with the large bevel gear b, on the differential gear case c. On the inside of this gear case are carried a number of small bevel gears, one of which is shown in section at d. These are free to turn on the studs that hold them to the gear case. These gears in turn mesh with bevel gears e and f, on the ends of the half axles.

The principle governing the action of the bevel gear differential is similar to that of the spur gear differential. When the two bevel gears e and f on the half axles meet with the same resistance, the small bevel gears d do not turn on their bearings; but when the movement of one of the gears e or f is resisted more than

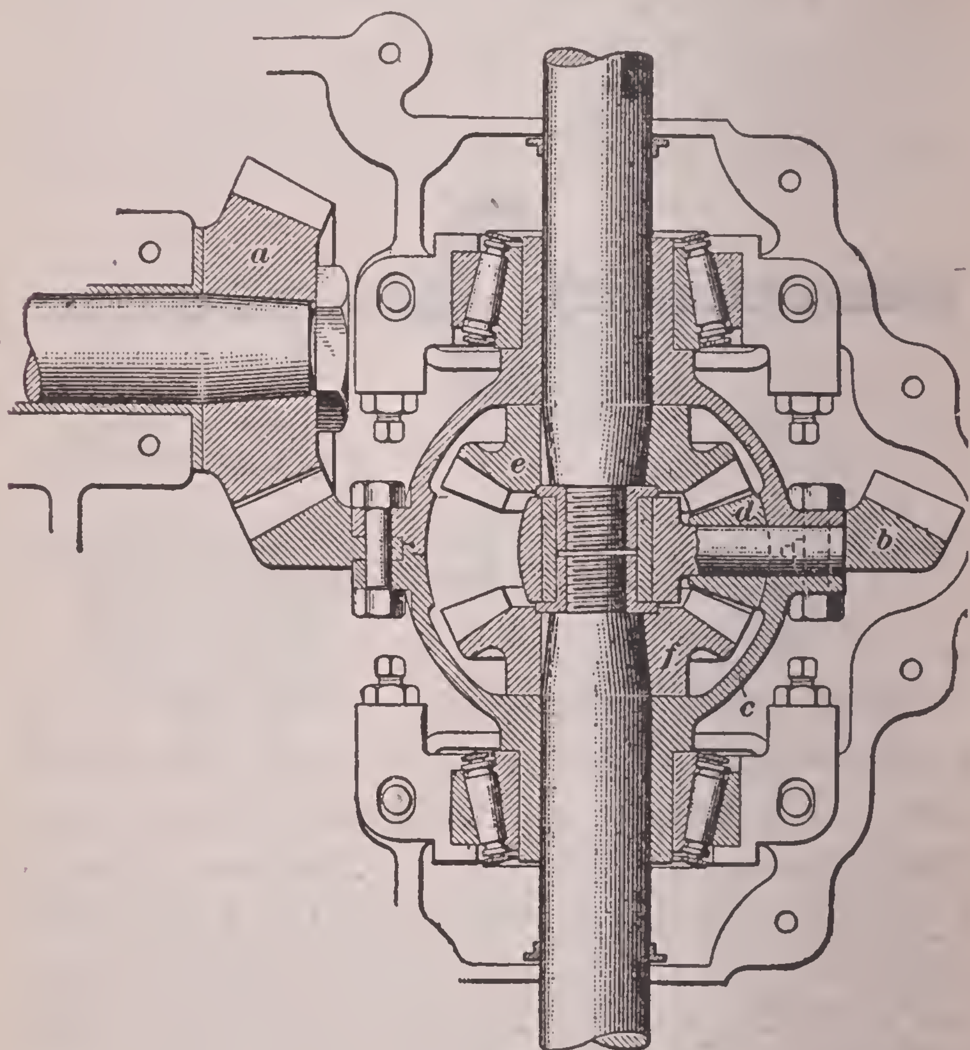


Fig. 118

that of the other it lags behind, causing the small bevel gears d to turn on their axles sufficiently to equalize the resistance.

Spur Gear Differential. In the spur differential, bevel gears are replaced by gears of the spur type, as shown in Fig. 119, a large spur gear being secured to each half axle, as shown at A and B, exactly as are the bevel gears. A double set of spur pinions, E and F, having their bearings in the frame, revolve

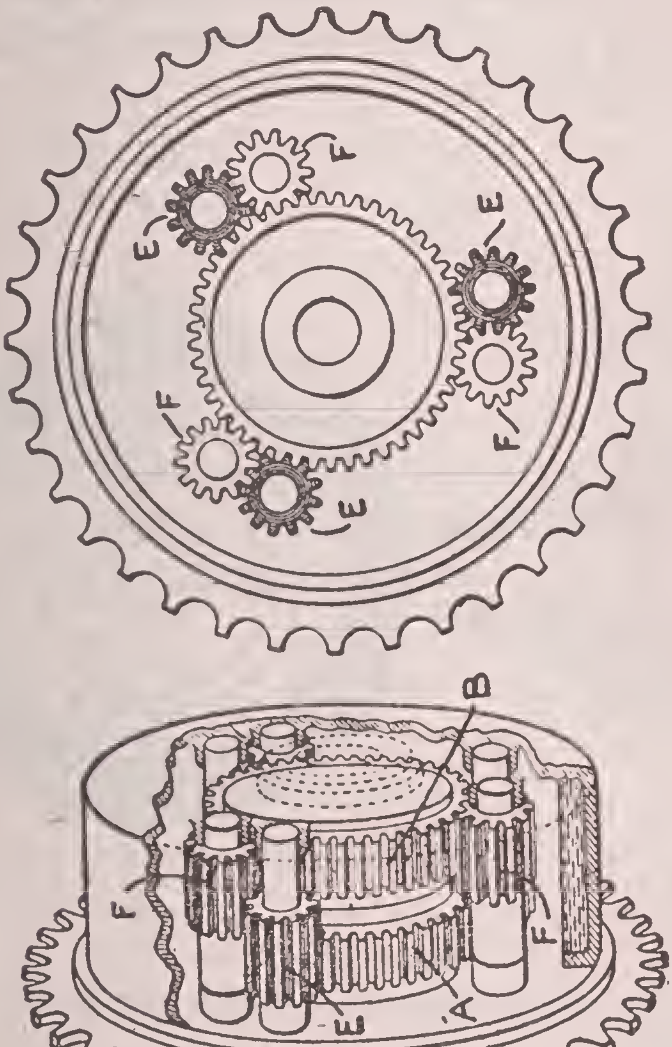


Fig. 119
Spur Gear Differential

upon axes parallel with the axle. For each bevel pinion is substituted a pair of spur gears, E and F, which mesh with each other, and at the same time each one of them is in mesh with one of the large gears. The combination of the motion of each pinion of the pair upon its gear, and the motion of the pair upon each other produces the same effect as the use of a bevel pinion. When the vehicle is rounding a curve, one rear wheel moves less rapidly, causing the pinions with which it is geared to revolve upon their bearings, and thus compensate for the increased resistance.

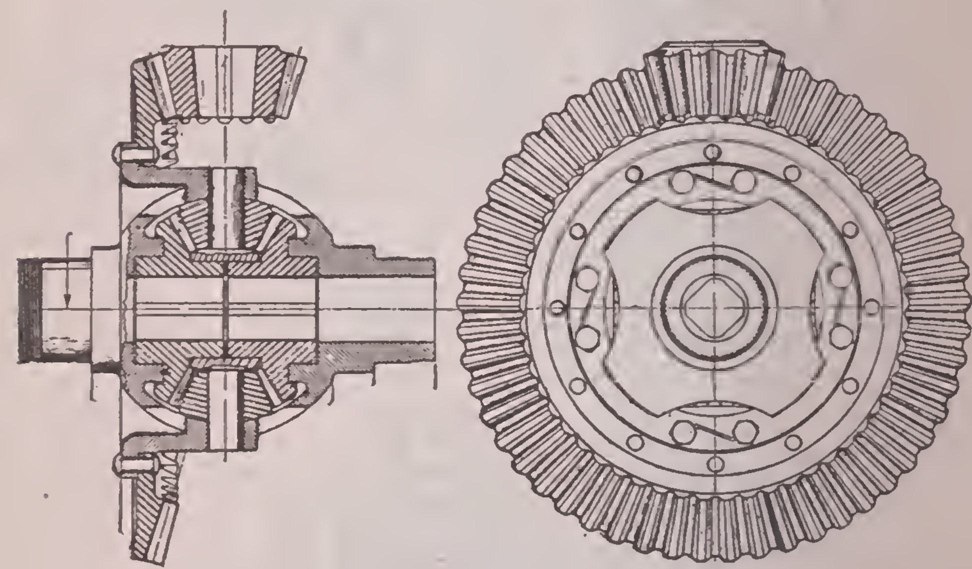


Fig. 120
Sectioned and Side View of Bevel Gear Differential

Testing Differential Gears. The differential gear should be tested with a view to locating any wear or side play. This may be done by jacking up the rear axle and shaking one wheel forward and backward while the other is held stationary, and noting how far the wheel must be turned before the movement is taken up by the flywheel of the engine. Any noticeable play will generally be found either in the center pinions of studs of the differential gear, in the large and small bevel gears, in the clutch sleeve, or in the universal joints. The differential gear, and live axle of modern cars seldom give trouble if kept properly lubricated, and the car's mileage should run up into many thousands before any considerable amount of play is evident. The joint pins of the propeller shaft may become loose through wear, in which case a knocking noise in the transmission gear will indicate the cause and location of the trouble. These pins may be readily replaced with new ones at small cost. If the play is found in the bevel gears, the small gear should be adjusted to mesh deeper with its larger mate. This may be done by means of the adjustable locking ring or by inserting a washer of the proper thickness. It may be found, however, that no adjustment is necessary, and a thorough cleaning with gasoline to remove all oil and grease will be all that is required. The case should then be refilled with the quantity of oil and grease recommended by the manufacturers.

Driving, Automobile. When on the open road, away from cities or towns, the following rules should be borne in mind. (1) Drive with moderate speed on the level, slow speed down hill, and wide open throttle for hill climbing, or getting up speed only. (2) The condition of the road should be noticed, the presence of mud or dust thereon furnishing sufficient reason for slowing down somewhat for the sake of other road users. (3) The ordinary rules of the road regarding the negotiation of turns, and crossings, also the overtaking or passing of other vehicles should be adhered to, even though a lower rate of speed is involved thereby. (4) A sharp lookout should always be kept for traffic of all kinds, as well as on approaching schools, churches, or public buildings, and also for road signs indicating danger, caution, etc. (5) When on the road the autoist should show courtesy to other road users. Courtesy in autoists is much appreciated, and goes a long way toward removing the prejudice which exists in many places against automobiles.

In passing another vehicle going in the same direction, turn out at least 75 feet back of it so that you have a clear view of the road ahead. If another vehicle is coming toward you and near at hand, do not try to pass.

When preparing to turn or stop always signal to drivers behind with your hand and avoid stopping suddenly.

GEAR—CHANGING. In changing gears the autoist should endeavor to have the motor and car moving at nearly corresponding rates of speed before the clutch is engaged. With the planetary type of gear, changing is simple, and drivers usually guess at the proper period at which to make the change, any mistake in estimating the rates of the car and motor being of little consequence, as the bands will slip instead of transmitting the shock to the gear. A similar action occurs in the case of individual clutch or friction gears, but with the sliding type severe strains and shocks have to be taken up by the clutch, and are usually transmitted in part to the gear if the clutch is not slipped. What applies to the sliding type in general applies to the other types as well.

In changing from a lower to a higher gear it will be necessary to speed up the motor by means of the throttle or accelerator in order to store enough energy in the flywheel to furnish the work needed to accelerate the car to its new speed. As the speed of the car increases the higher gear should be engaged, the autoist not being in too great a hurry to make the change. The movement of the change gear lever should be made quickly in order that the car does not lose way. When changing from a higher to a lower gear the change should be made as quickly as possible before the car has time to slow down. When climbing a steep hill it should be ascended as far as possible on the high gear by proper use of the throttle and spark, and the change down to the lower gear made as soon as the motor begins to labor or is in danger of stopping. The presence of an unusual number of passengers in the car will affect its ability to negotiate grades which ordinarily are taken on the high gear, and the autoist should remember this and not attempt to force the car to travel on that gear with the increased load, but resort to a lower gear.

Reversing—Backing Up. Among other things connected with driving which is apt to be neglected, is reversing, or driving a car backward. Usually a car is never reversed for more than a few yards at a time and the maneuvering involved requires no great skill. Steering a car when running backwards is diametrically opposite to that when running forward. A turn of the wheel to the left steers the car in the opposite direction to the right, and vice versa. The usual mistake made in reversing is in turning the steering wheel too far, and describing zigzags in the road as a result. The autoist should remember that the reverse gear of a sliding change gear should never be engaged until the car has been brought to a full stop.

Brakes, Proper Use of. Next to the motive power in importance come the brakes. There are a number of points regarding brakes that every autoist should know and remember. First and most important is the fact that brakes vary in their effectiveness, and that freedom from disaster depends upon the brakes being kept in good condition and properly adjusted. Second, while a brake may be perfectly satisfactory for slowing down, it by no means follows that it will bring a car to a stop as it should, nor hold the car from going backward. Third, brakes should be tested frequently with the car in motion, the pedal or hand lever being applied until the car slows down, or stops. The distance covered in making this test should be noted, and a greater distance allowed in making stops on the road.

In applying brakes, the application should be gradual, reducing the speed of the car as quickly as possible without locking the wheels. As long as the tires retain their grip on the road, the powerful retarding action of the brake continues, but when the wheels are locked the brakes have little or no effect, and the car will either slide along, or skid, in either case being beyond the control of the driver. Should the wheels become locked while descending a hill, the brakes should be released until the wheels are again revolving, and then reapplied gradually, until they act satisfactorily.

Brakes should be examined at regular intervals in order to ascertain if the lining is in good condition. If worn, the old lining should be replaced with new. If the brakes are of the internal-expanding type, the shoes may have become worn, in which case they should be renewed. Toggle joints and adjusting nuts should be inspected, and any looseness taken up. Brakes should be adjusted on the road, as any improper adjustment of the equalizer bar will have a strong tendency to make the car skid. Both brakes should be adjusted alike, that the braking force applied by the equalizer may be transmitted to the wheels equally.

Side Slip, or Skidding. If the rate of rotation of a wheel is greater than the rate of advance over the road, the wheel loses adhesion and thereafter it is just as easy for it to move in one direction as in another.

The wheel can now slip sideways as easily as it can slip forwards, particularly when it has the rounded section slightly flattened, which is the case with pneumatic tires. When traveling straight ahead, and with the motor out of gear, skidding does not usually occur. A slight turn given to the steering wheel checks the speed and introduces a side pressure on both front and rear wheels, due to the machine tending to continue its path in a straight line. Generally this side pressure will not cause skidding. If, however, the motor be suddenly thrown in gear, or the brakes suddenly applied, or, what amounts to the same, a large turn is given the steering wheel, the wheels find themselves either rotating more than in proportion to their advance, or advancing more than in proportion to their rotation. This immediately causes a loss of adhesion, which, once established, causes the car to skid or side-slip.

SPARK—REGULATION OF. Upon the proper use of the sparking device depends the economy of the motor, and in many cases the safety of the driver. On some cars the sparking point on the magneto is fixed, and the autoist controls the car by the throttle only. There are a number of cars in use which employ the battery in connection with separate coils or a single spark system, or a magneto on which the spark can be regulated by the driver. When starting, the spark should be retarded in the case of battery ignition, to prevent backfiring, and slightly advanced to a certain point, depending on the motor and magneto, in the case of magneto ignition. When it is desired to slow the motor down below the point obtained by throttling only, the spark is likewise retarded. In ordinary running, a position of the spark lever can be found which will give fair average results through a considerable range of speed without changing its position, and this position varies with each motor, and can be found by experience. When a higher rate of speed is desired, the throttle is opened and the spark advanced gradually. If a grade is to be negotiated it should be "rushed" if possible, the throttle being opened full and the spark well advanced until the motor begins to slow down and "knock," when the spark should be retarded to correct this. The autoist should always keep the spark as far advanced as possible, without causing the motor to knock.

When to Retard the Ignition. Always re-retard the ignition before starting the motor, and take great care that the ignition is retarded and not by mistake advanced. Some cars are fitted with a device which prevents the starting crank being turned unless the spark is retarded. If it is not clear as to which way to move the ignition lever to retard the ignition, move the commutator in the same direction as the camshaft rotates.

As soon as the motor slows a little when going uphill, retarding the spark enables more power to be obtained from the motor at the slow speed, that is to say, if the spark is not retarded the motor will go slower than if it is retarded. Do not retard the lever to the utmost under these conditions; on the contrary, retard the lever to such a point that the knocking (due to the wrong position) ceases.

Retarding the spark causes the maximum pressure of the explosion to occur at the best part of the stroke, or, rather, the mean pressure of the explosion stroke will be lower if the best point of ignition by retarding is not found. This is a matter of some skill and practice.

To slow the motor, cut off as much mixture as the throttle allows, then slow the motor still further by retarding the spark, but on no account retard the spark when the throttle is full open (for the purpose of slowing the motor), as the motor will merely discharge a quantity of flame at a white heat over the stem of the exhaust valve, burning it, softening it, and making it scale.

When to Advance the Ignition. With too early ignition the pressure upon the piston becomes excessive and without any adequate return of useful work or energy. If the ignition be retarded too much, the maximum explosive pressure occurs too late during the working or power stroke of the piston, and the combustion of the gases is not complete when the exhaust-valve opens. Greater motor speed requires an early ignition of the charge, but greater power calls for late or retarded ignition.

The reason for advancing the spark when fast running is required, is that the explosion or ignition of the charge is not instantaneous as may be supposed, but requires a brief interval of time for its completion.

It may be well to explain without entering into theoretical details, that when a motor is running at normal speed, the ignition-device is so set that ignition takes place before the piston reaches the end of its stroke. The later the ignition takes place the slower the speed of the motor and consequently the less power it will develop. If, however, in starting the motor the ignition-device were set to operate before the piston reached the end of its stroke, backfiring would occur, resulting in a reversal of the operation of the motor and possibly in injury to the operator.

Car Inspection. Most autoists are content to make all their inspection of the car and its mechanism from above, and rarely give more than a casual glance below the frame except when trouble occurs. On cars fitted with pressure-feed on the gasoline, the piping should be frequently inspected, on account of the danger from fuel leakage. Such inspections should be made when the motor is stopped, and the pressure still turned on. The tank should be gone over for leaks arising through the opening of its seams from vibration, or the loosening of the union connecting the fuel lead with the tank. The lead and its connection to the carbureter should also be examined for leaks and abrasions due to rubbing against other parts of the mechanism. If any such are found they should be immedidiately repaired. Twine, tire tape, or rubber bands will act satisfactorily as fenders to prevent further mischief. Unions which cannot be made tight by screwing up should be taken apart and the male connections coated with soap or red lead, which will render them tight for a considerable time.

After going over the fuel system, the brake rods and steering connections should be examined for loose joints and broken oil and grease cups. Grease boots on the drive-shaft joints should be seen to be sound, and filled with grease. A cleaning out of the dirt from the interior of the mud-pan will often reveal lost cotter pins or nuts, and tend to a more agreeable handling of the draincocks, carbureter and filter. This time will be well spent when the chances of fire or accidents arising from faulty steering or brake connections are taken into account.

DONT'S. In the first place don't forget to ascertain the fact that the ignition mechanism is retarded before cranking the motor. Many a sprained wrist and a few cases of broken heads or arms have been caused by the neglect of this simple precaution. It is a good plan to have the ignition-control spring so actuated that in its normal position it is always retarded.

Don't use the electric starting motor to propel the car. It ruins the battery.

Don't use a match or a small torch to inspect the carburetor. It sometimes leads to unexpected results.

Don't forget to fill the gasoline tank before starting.

Don't smoke while filling the gasoline tank.

Don't take out all the spark plugs when there is nothing the matter, except that there is no gasoline in the tank.

Don't forget to always have an extra spark plug on the car.

Don't allow the motor to race or run fast when out of gear. If the car is to be stopped for a few minutes, without stopping the motor, retard the ignition and also throttle the charge, so that the motor will run as slowly as possible.

Don't fill the gasoline tank too full, leave an air space at the top or the gasoline will not flow readily.

Don't put grease in the crank case of the motor, it will clog up the oil holes and prevent the oil from circulating.

Don't fill the gasoline tank by lamp or candle light, something unexpected may happen.

Don't keep on running when an unusual noise is heard about the car, stop and find out what it is.

Don't start or stop too suddenly, something may break.

Don't pour gasoline over the hands and then rub them together. That rubs the dirt into the skin. The proper way to do is to saturate a towel with gasoline and then wipe the dirt off.

Don't forget to examine the steering gear frequently.

Don't fail to examine the pipe between the carbureter and the admission-valve occasionally. The pipe connections sometimes get loose and allow air to enter and weaken the mixture.

Don't forget to see that there is plenty of water and gasoline in the tanks.

Don't fail to clean the motor and all the wearing parts of the car occasionally.

Don't forget to oil every part of the motor where there is any friction, except the valve stems.

Don't forget to put distilled water in the battery every ten to fifteen days.

Dynamometer. A dynamometer is a form of equalizing gear which is attached between a source of power and a piece of machinery when it is desired to ascertain the power necessary to operate the machinery with a given rate of speed.

Electricity, Forms of. Electricity or electrical energy may be generated in several ways—mechanically, chemically and statically or by friction. By whatever means it is produced, there are many properties which are common to all. There are also distinctive properties. The current supplied by the storage battery will flow continuously until the battery is practically exhausted, while the current from a dry battery can only be used intermittently; that is, it must have slight periods of rest.

The dynamo or magneto current is primarily of an alternating nature, or one which reverses its direction of flow rapidly. In use, this alternating current is changed into a direct or continuous current flowing in one direction only, by means of a commutator. Any of the forms described are capable of igniting an explosive charge in a motor cylinder, but the static or frictional form of electricity is not used for this purpose on account of its erratic nature.

Electromotive Force, Definition of. The cause of a manifestation of energy is force; if it be electric energy in current form it is called electromotive force. An electromotive force or pressure of one volt will force one ampere through one ohm of resistance.

Engines, Internal Combustion.

Engine—Construction of. An automobile engine should answer the following requirements in order to meet the demands of the motor user: It must be of light weight in proportion to its horse power, so that as large a proportion of its power as possible may be available for propelling the useful load, and but little demanded to move its own weight; it must be compact, in order that it shall not occupy too large a proportion of the available room of the car; it must operate without undue noise and vibration; it must be fully enclosed as a protection against the weather, and still it must be so located as to be easily accessible for inspection, oiling and repairs; its operation must be automatic for considerable periods of time, as regards cooling and lubrication; it must be capable of running very slowly, or very fast at will, and of developing little, or much power: it must be supported upon the car in such a manner that its power may be most readily and efficiently transmitted to the driving wheels, and it must further be carried upon springs so that the jar and shock from the road shall not be transmitted to it.

Explosive Motors. Explosive motors are of three forms, known as stationary, marine and automobile. Their general characteristics are implied by their various designations. The stationary motor may be either vertical or horizontal. Marine motors, designed for application to boats, are almost invariably vertical. Automobile motors are of comparatively recent introduction and of great variety, the aim of the designers being to secure the maximum of power and minimum of weight. They also may be vertical or horizontal.

These three forms may be again divided into two-cycle and four-cycle types. In the former an explosion occurs at every revolution. In the latter there is an explosion at every alternate revolution.

Explosive motors are dependent for successful operation on two things: First, a charge of gas or vapor, mixed with sufficient air to produce an explosive mixture, and second, a method of firing the charge after it has been taken into the combustion chamber of the motor.

When coal gas is used the supply is taken from the main and mixed directly with the necessary proportion of air. When gasoline is used, air is mixed with it in the correct proportion by carbureting devices.

After the charge of gas and air has been taken into the cylinder it is compressed, as will be shown later, by the action of the motor itself and then fired, usually by an electric spark actuated by the motor, but sometimes by the use of a tube screwed into the cylinder and

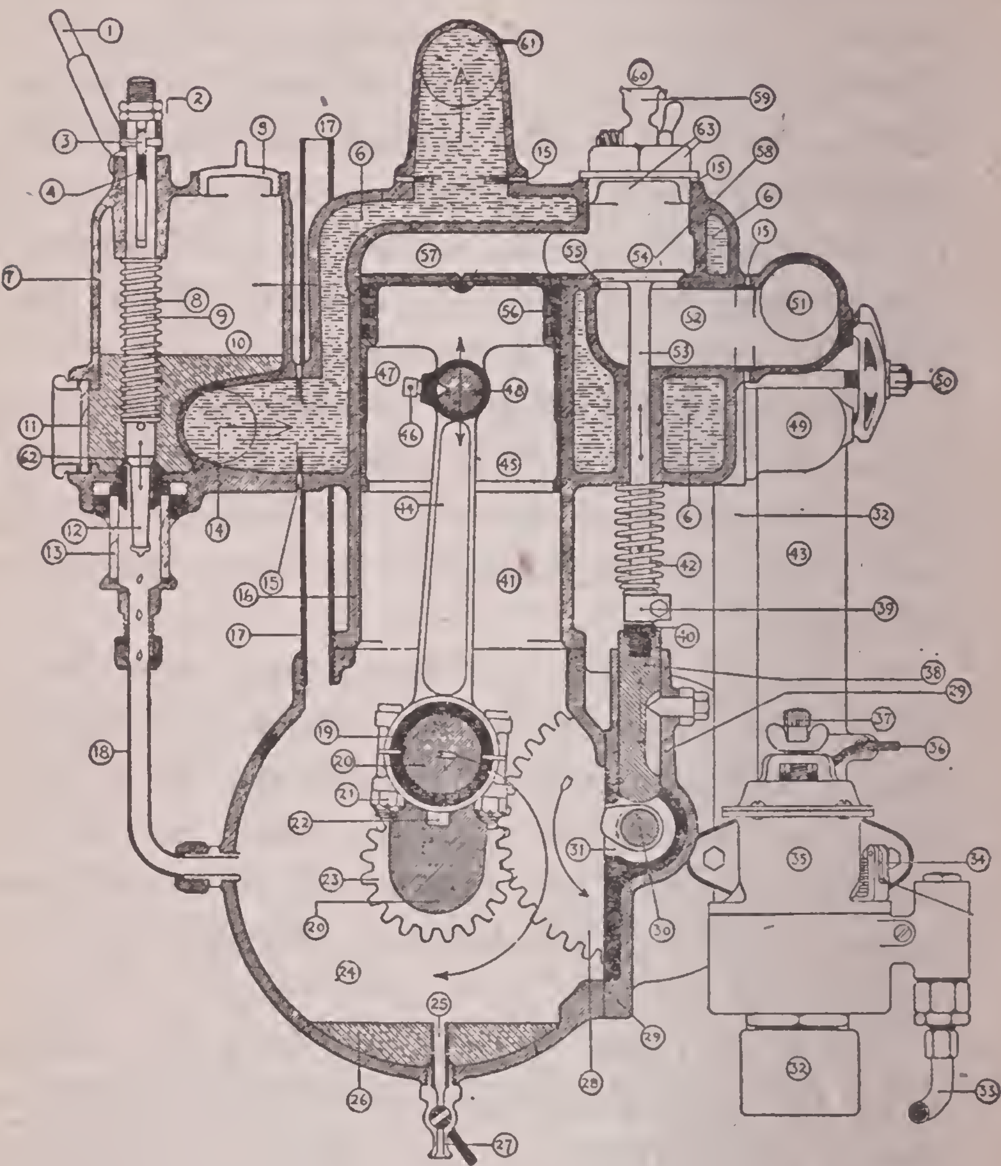

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63

Fig. 121

Interı ıl Combustion Automobile Engine. 1, Oil Val e Lever. 2, Oil Valve Adjustment. 3, Oil Val e Lifter. 4, Oil Valve Slot. 5, Oil Tank Co ɪr. 6, Water Jacket. 7, Oil Tank. 8, Oil Val e Spring. 9, Oil Valve Plunger. 10, Oil. 11, Oil Gauge Glass. 12, Oil Valve. 13, Oil Feed Wi low. 14, Water Inlet. 15, Cylinder Joint. 16, Cylinder Wall. 17, Crank Case Breather. 18, Oil Feed Pipe. 19, Connecting Rod Bearing. 20, Crank Pin. 21, Rod Bearing Bolt. 22, Oil Scoop. 23, Crank Shaft Timing Gear. 24, Crank Case. 25, Oil Lever Overflow. 26, Crankcase Oil. 27, Oil Drain Cock. 28, Cam Shaft Timing Gear. 29, Cam Shaft Plate. 30, Cam Shaft. 31, Cam Shaft Housing. 32, Exhaust Outlet. 33, Gasoline Pipe to Carburetor. 34, Carburetor Priming Lever. 35, Carburetor. 36, Throttle Lever Rod. 37, Gasoline Adjustment. 38, Valve Lifter Rod. 39, Valve Stem Adjustment. 40, Fibre in Valve Plunger. 41, Cylinder Space. 42, Valve Spring. 43, Exhaust Pipe. 44, Connecting Rod. 45, Piston. 46, Wrist Pin Set Screw. 47, Oil Groove in Piston. 48, Wrist Pin. 49, Exhaust Manifold. 50, Manifold Clamp Nut. 51, Intake Manifold. 52, Intake Passage in Cylinder. 53, Valve Stem. 54, Valve Head. 55, Valve Opening, Seat and Face. 56, Piston Rings. 57, Combustion Space. 58, Valve Pocket. 59, Priming Cup. 60, Valve Cap. 61, Water Outlet Header. 63, Valve Cap.

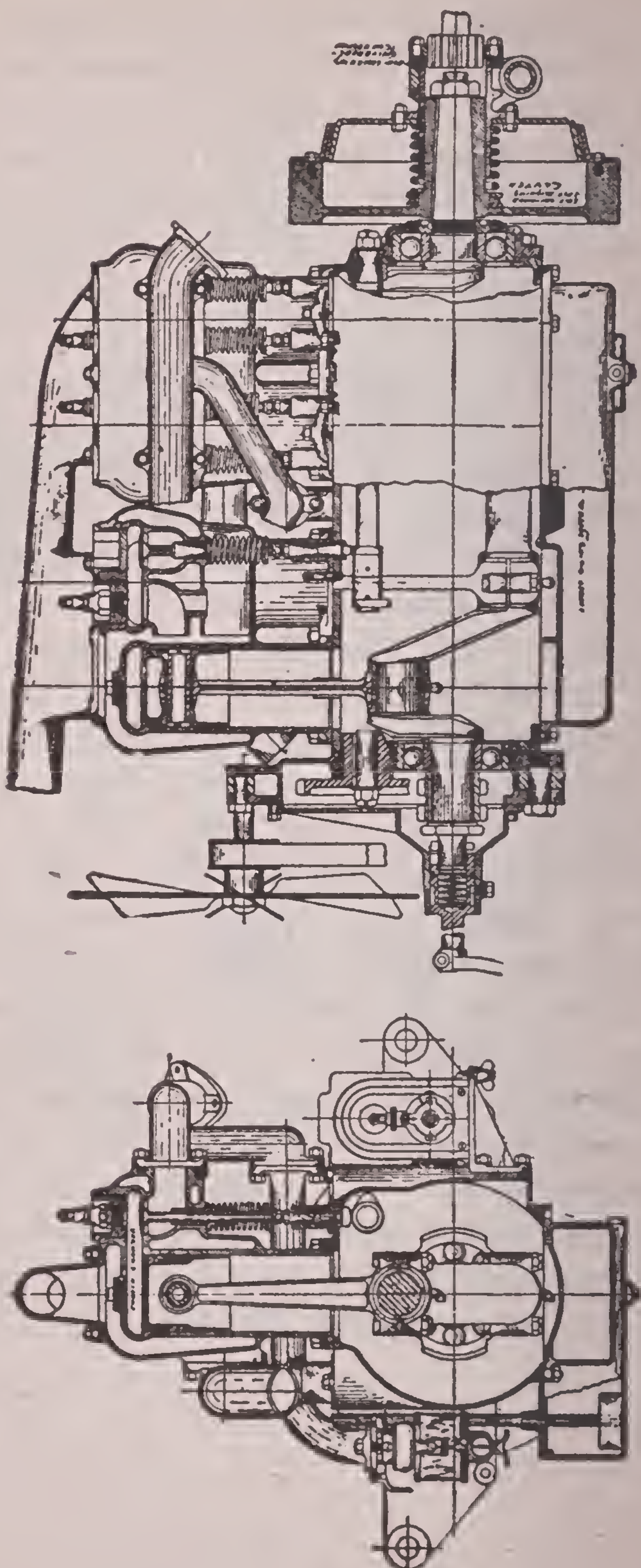


Fig. 122
Front and Side View of Section Through Four Cylinder Automobile Engine

heated from the outside, the heat, of course, being communicated to the gas. The resulting explosion operates the motor.

The principal parts of a four-cycle explosive motor are the cylinder, the piston, the piston rings which fit into grooves in the piston: two sets of valves, one to admit the charge and the other to permit it to escape after the explosion; a crank shaft and connecting rod which connect it with the piston head, and a flywheel, whose presence insures steady running of the motor, and whose further functions will be better understood as the description proceeds. In the two-cycle form of motor there is really but one valve, the exhaust and admission-ports being covered and uncovered by the piston itself.

All of the parts referred to are of the motor proper. Other parts, which are separate from the motor but on which its operation depends, are the carbureter, which supplies the charge of gasoline vapor and air for a gasoline motor, or a mixing chamber for mixing air and gas in the case of a gas motor, and the batteries and other parts of the electrical ignition device.

A part which has no connection with the actual running of the motor but with which practically all are fitted is the muffler, whose purpose is to deaden the sound of the explosion.

The cylinders of all except very small motors are as a rule partly encased in a chamber through which water is circulated, the object of this being to keep the cylinder cool.

In other cases a current of cool air is sent around each of the cylinders by means of ducts and one or more fans, this air acting as a direct cooling agent.

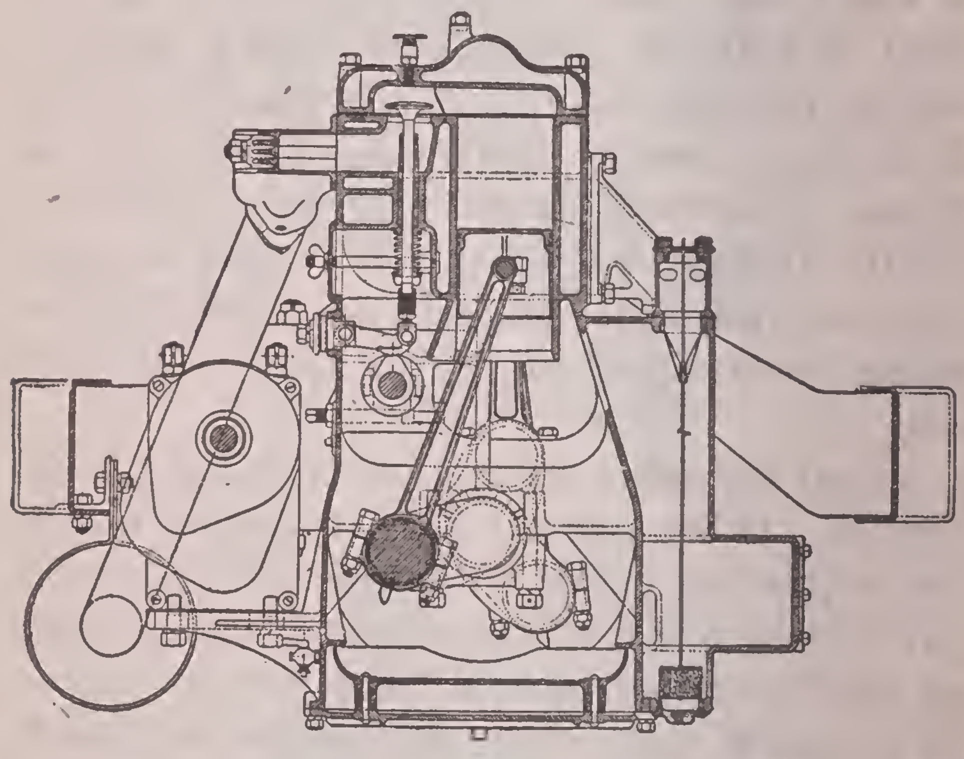


Fig. 123

Section Through Six Cylinder Long Stroke Engine

PISTONS. The piston used in a gasoline motor cylinder is of the single-acting or trunk type. It is made of an iron casting which is a good working fit in the cylinder. Around the upper end of the piston three or four grooves are cut, and in these grooves the piston-rings fit. The rings are made of cast iron, and the bore of the ring being eccentric to its outer diameter, there is a certain amount of spring in them, and so pressure is caused against the cylinder wall, preventing any of the expanding gases passing the piston.

PISTON MATERIALS. Until recently it has been the universal practice to make internal combustion engine pistons of cast iron for the reason that this material does not warp under heat to such an extent as does steel. The principal objection to cast iron has been its comparatively high weight, this weight being necessary because of the lack of great strength in the metal. It is a well known fact that cast iron is very brittle. With the advent of the modern high speed engine, experiments were conducted with steel pistons because of the fact that they allowed of lighter construction with equal strength. Steel pistons have done satisfactory work, but are very high in production cost, and this has prevented their general introduction.

The necessity for reducing the weight of the reciprocating parts has more recently led to the introduction and use of pistons made from alloys of aluminum, which, of course, gives the desired reduction in weight. The fit of the piston in the cylinder cannot be so tight when cold as with cast iron or steel, but as soon as the engine has run a few moments, the expansion due to heat allows the piston to fit close enough for all practical purposes. These pistons are now fitted in many makes and models of stock cars and may be fitted to cars already in use.

PISTON DISPLACEMENT. The piston displacement of a motor is the volume swept out by the piston, and is equal to the area of the cylinder multiplied by the stroke of the piston. The expression, cylinder volume, is sometimes confounded with the term piston displacement. This is erroneous, as the cylinder volume is equal to the piston displacement, plus the combustion space in the cylinder head.

PISTONS, LENGTH OF. For vertical cylinder motors the length of the piston should not on any account be less than its diameter, while a length equal to one and one-quarter or even one and one-third diameters is better. For motors with horizontal cylinders the length of the piston, in any case, should not be less than one and one-third diameters, and if possible one and one-half diameters or over.

PISTON POSITION. There is nothing more confusing to many motorists—not only to the beginner, but to many who are proficient in the general care and operation of their motor cars—than the relative various positions, in a four-cycle engine, of the four pistons on any of their four cycles of compression, work, explosion, and exhaust, this being the order of the cycles.

In the following illustrations the pistons are shown as they are usually placed in relation to

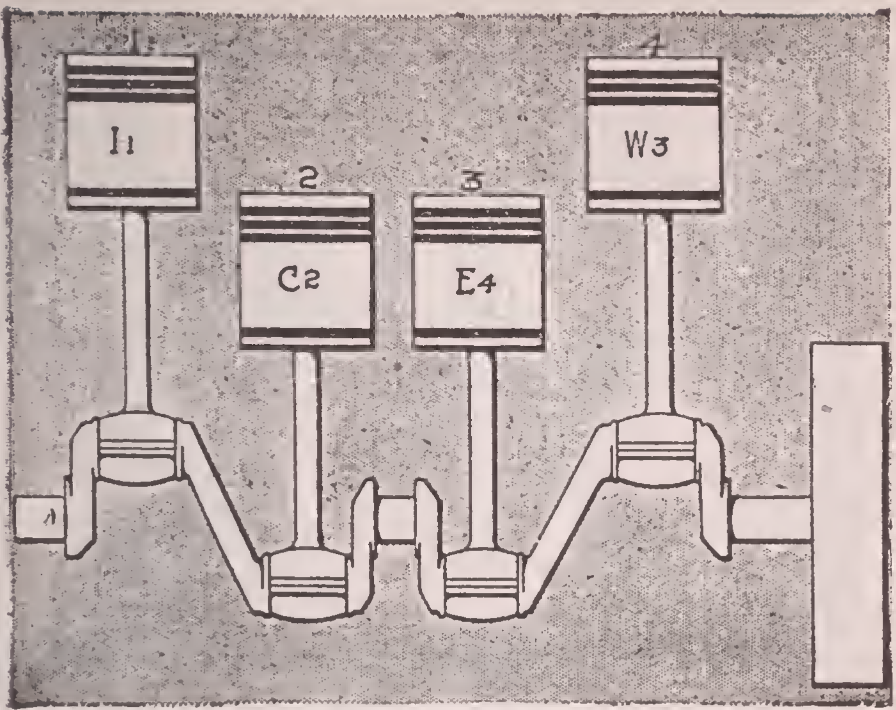


Fig. 124

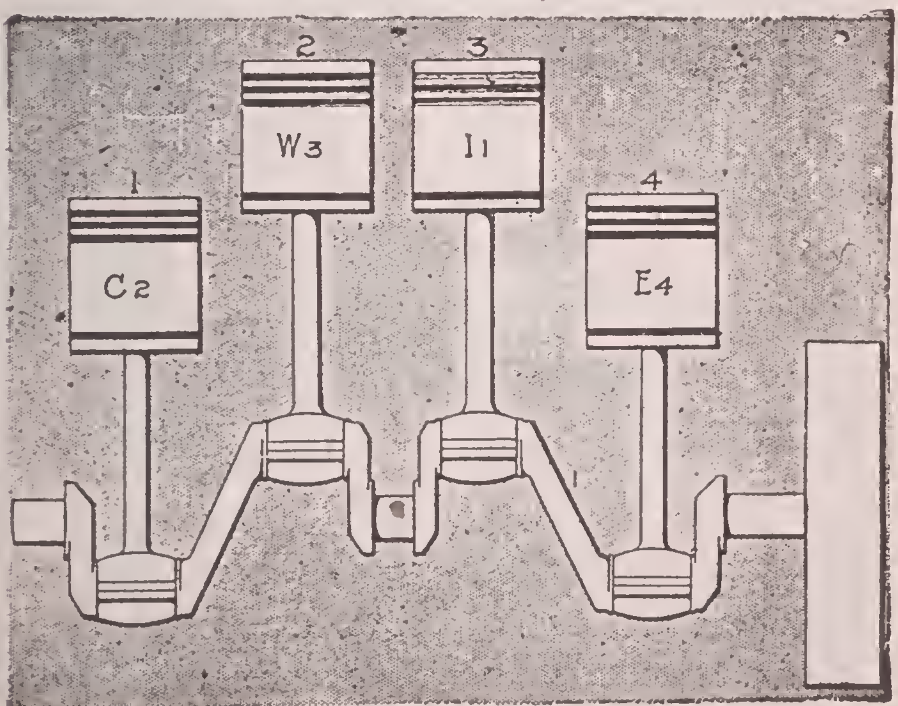


Fig. 125

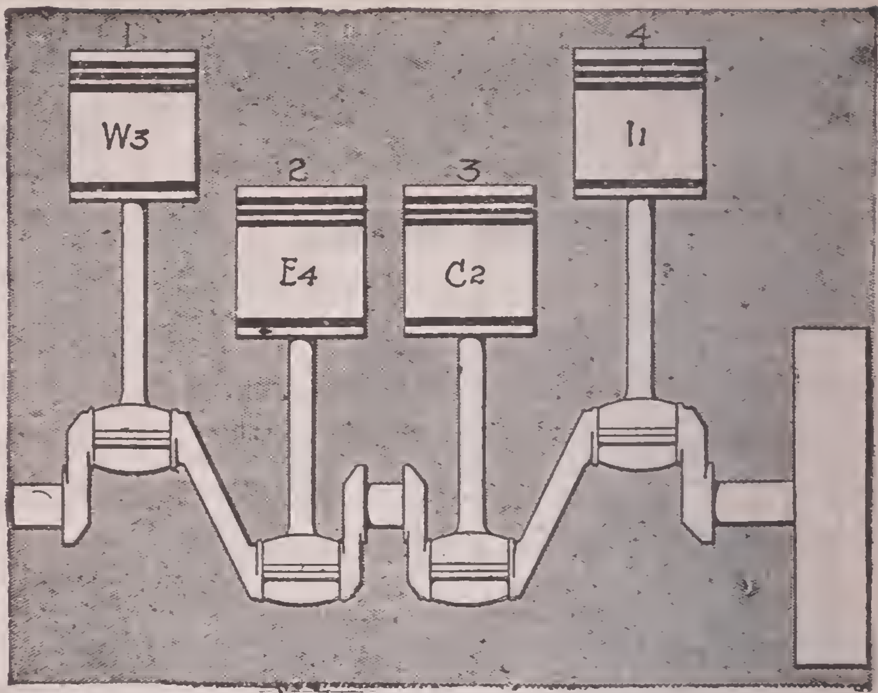


Fig. 126

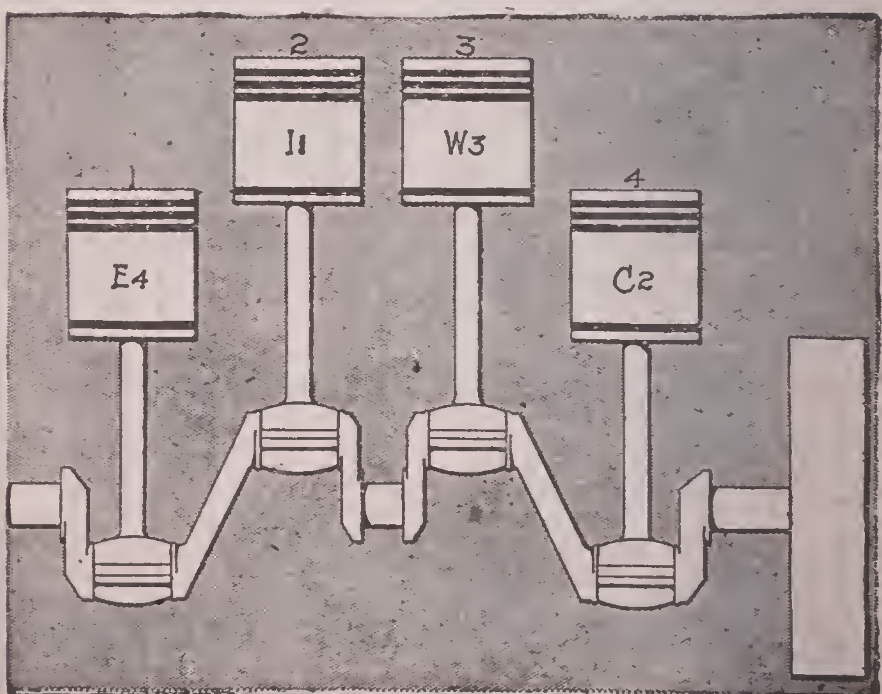


Fig 127

one another. That is, pistons 1 and 4 are at the top of their strokes when pistons 2 and 3 are at the bottom, and, obviously, vice versa. The figures over the pistons in each diagram represent their order of number, counting from either end of the engine.

In Fig. 124, cylinder 1 is ready to descend on its intake stroke—having finished its exhaust stroke—and cylinder 4 is ready to descend on its working stroke—having finished its compression stroke. Cylinders 2 and 3 are ready to move on their up strokes, No. 2 on its compression, having finished its intake, and No. 3 on its exhaust, having finished its working stroke. The results are that the pistons are brought into the positions shown in Fig. 125. This means that cylinder No. 1, having completed its intake downward stroke, is ready for its compression up stroke; No. 2 has moved up on compression and is ready to go down on work; No. 3 has finished exhausting and is ready for intake and No. 4 has finished the work stroke and is ready to move up on exhaust. Piston No. 2, having completed its work stroke, the pistons are brought back to the positions shown in Fig. 124, but with an altered condition of the cycle represented by each, as shown in Fig. 126. The pistons are now ready to move to the positions shown in diagram 2, with an altered cycle condition. Cylinder No. 1 moves down on work; No. 2 up on exhaust;

No. 3 up on compression and No. 4 down on intake, see Fig. 127.

When the cycle of each has been completed, from the above starting points of No. 1, exhaust; No. 2, intake; No. 3, work, and No. 4, compression, the pistons are then back not only in the position of Fig. 124, but with the same condition of cycles.

This explanation has been in the order of the cylinder numbers, but the effect of each cycle of each cylinder will be easier traced if it be remembered that the order in which the cylinders work is: Cylinder 1, then cylinder 3, then cylinder 4, and then cylinder 2, and then repeat indefinitely. From this and the above illustrations it will be easily understood that as piston No. 1 goes down on its work stroke, No. 3 comes up on compression stroke, and is then ready for the work, which is a down stroke bringing No. 4 up on compression. No. 4 then goes down on work and brings No. 2 up on compression, then it goes down on work and brings No. 1 up on compression for the repeating of cycles. This shows that each synchronized pair, 1-4 and 2-3, always have one cycle between them as they move together, either up or down.

Piston-Rings. To ensure proper compression, it is absolutely essential that the piston-rings should be kept lubricated; consequently when the motor has been idle for some time, the compression at the start is often poor. Any failure in the lubrication while running will, of course, have the same effect, such, for example, as in the case of overheating, or when the supply is intermittent. Sometimes the piston-rings get stuck in their grooves with burnt oil, through overheating, and the compression escapes past them. Thorough cleaning with kerosene, and fresh lubricating oil will settle the matter. In motors where the rings are not pinned in position, the slots may work round so as to coincide. In this case they will have to be moved around. Sometimes burnt oil may, apparently, have the opposite effect on piston-rings, for by causing the piston to grip in the cylinder, it will produce considerable resistance, and the operator might erroneously think in consequence that his compression is good. In every case, after a long-run, a little kerosene should be injected into the cylinders to clean the rings.

Many of the specially prepared carbon removers will also act to clean the piston rings.

FLYWHEELS. One of the first and most important considerations in connection with the construction of a gasoline automobile motor is the proper diameter and weight of the flywheel. If the diameter and weight of the flywheel be known, the speed of the motor or its degree of compression will become a variable quantity. On the other hand, if the speed of the motor and the degree of compression be fixed, the diameter or weight of the flywheel rim must be varied to suit the other conditions.

While it is true that the weight of the flywheel may be reduced as the number of cylinders is increased, there is a practical limit below which it is inadvisable to reduce the weight at the rim. Even should the number of cylinders be sufficient to cause a balance between the working strokes, it would still be desirable to add a rotating weight to compensate in some measure for the several reciprocating masses, such as pistons, connecting rods, crankshaft webs, etc. Engines have been built for racing purposes without flywheels, but they were unsuccessful.

Camshaft. Fig. 128 is a sectional view of a motor cylinder and illustrates the principle and action of the camshaft. In many motors one camshaft serves to open both intake and exhaust valves, while in other motors there is a cam-shaft for each set of valves. Besides opening the valves, the cams determine the length of time the valves remain open, also the speed with which it-opens and closes. Referring to Fig. 128, A is the crankshaft, P the piston, D is the cam-shaft which carries the cam E. The speed of the cam-shaft depends upon the type of engine. The one shown in Fig. 128 is driven at half the speed of the crank-shaft through the gear wheels B and C, B being one half the size of C. H is the valve to be opened, which in opening must be lifted off its seat. This is done when the cam E revolves and raises the roller G on the lower end of lifter rod F which extends upward resting against the lower end of the stem of valve

H, although between the two rods, or rather at their point of contact are nut and lock-nut L,

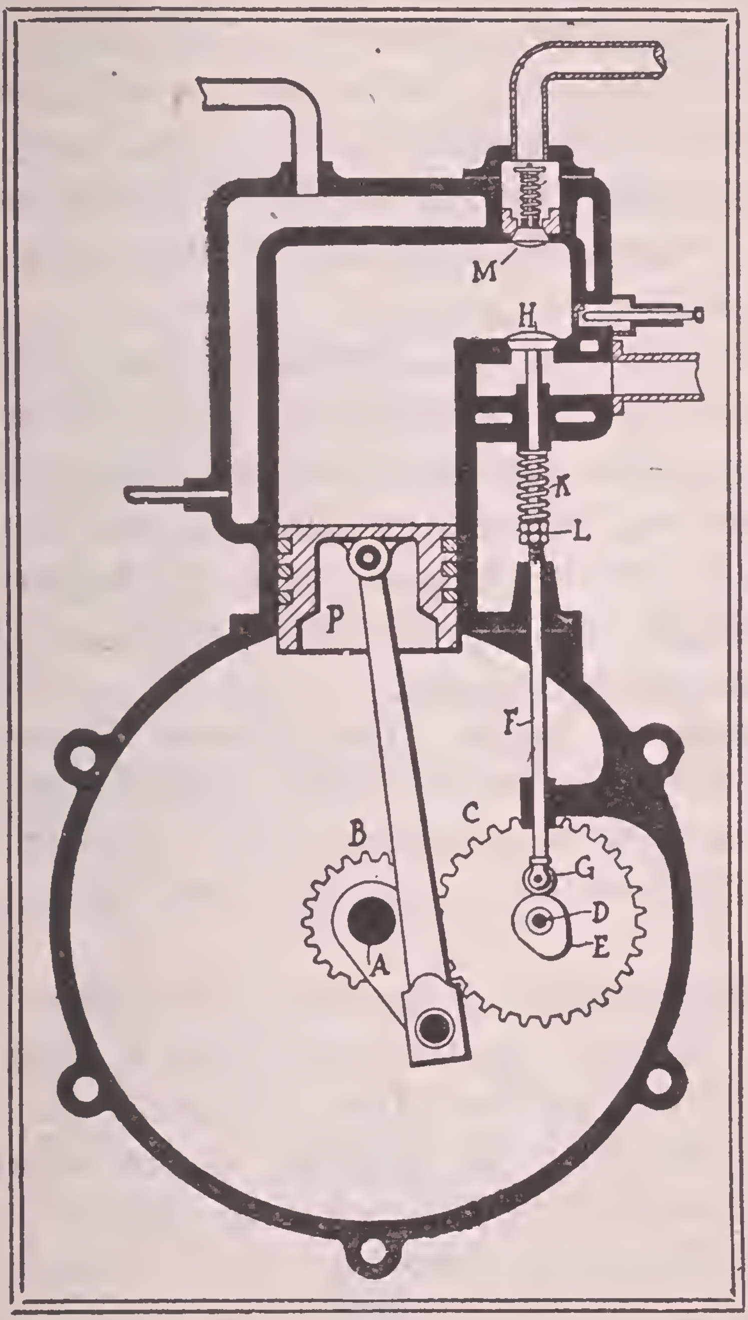


Fig. 128
A Camshaft and Its Location

for adjusting the length of F when timing the valve. K is a spiral spring, the function of which is to close the valve, after the cam E travels around and allows G to drop. Directly above valve H is the intake valve M, which in this case opens downward. This valve opens automatically, due to the suction of the piston in moving downwards on the intake stroke, but is kept closed during the compression and exhaust strokes of the piston, by the pressure in the cylinder.

Modern forms of construction make the camshaft and cams from one piece of steel, and the cams are then said to be integral with the shaft. This method makes it possible to place the cams in exactly the right position at the factory, and the danger of lost power from improper placing is thus greatly reduced.

Manifold, Inlet. The internal diameter of the admission or inlet-pipe leading from the carbureter to the admission-valve chamber should not exceed one-fourth the diameter of the motor cylinder.

This limitation is necessary in order to produce as great a partial vacuum as is possible in the admission-pipe. The carbureter should be placed as close as possible to the admission-valve chamber of the motor in order to secure the best results. Short turns or bends in the admission-pipe greatly increase the air-friction in the pipe, and at high speeds greatly diminish the volume of the charge drawn into the cylinder by the inductive or suction action of the motor-piston.

The desire to prevent condensation of the gasoline vapor in the inlet manifold has led many designers to fasten the carburetor flange directly to the cylinder casting at the point of entrance to the inlet valve passages. Others have either completely or partially water-jacketed the inlet manifold for its entire length. In all cases, the distance between the carburetor mixing chamber and the inlet valve port is made as short as possible.

A troublesome condition on many cars is that caused by minute air leaks in the inlet piping and connections. If carburetor adjustment is difficult, squirt liquid gasoline on the inlet connections with the engine running. Any change in engine speed is a sure indication that one or more air leaks exist.

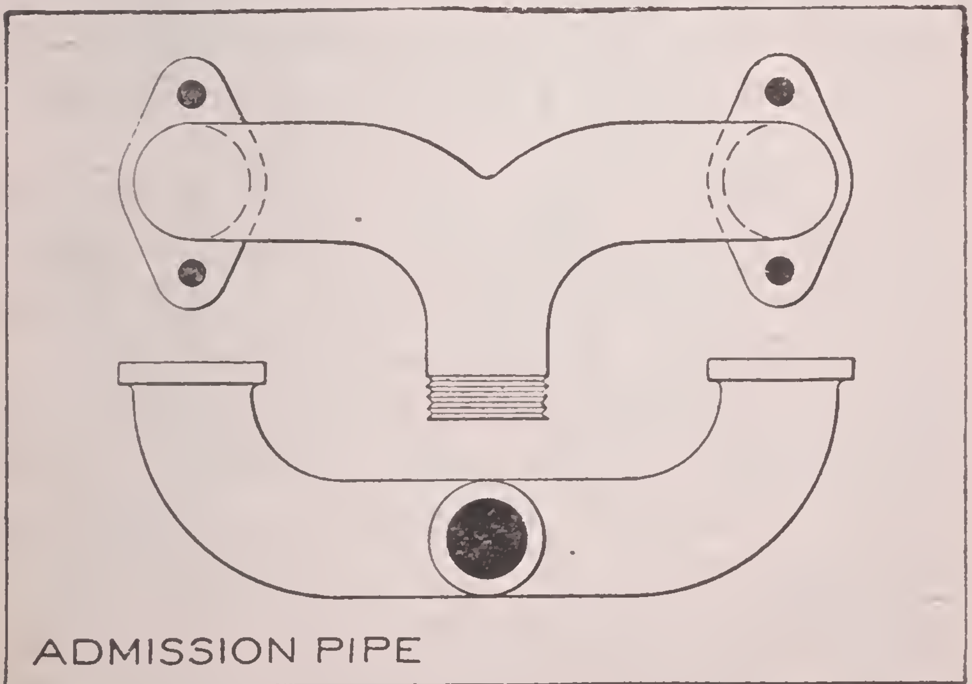


Fig. 129

The radius of curvature of the pipe on its center line should not be less than twice the outside diameter of the pipe. If space allows, a radius of three times the outside diameter of the pipe will give better results than two diameters.

COMBUSTION CHAMBER. That part of an explosive motor in which the gases are compressed, and then fired, usually by an electric spark, is known as the combustion chamber. The interior of the combustion chamber should be as smooth as possible and kept free from soot, or hard carbon deposits such as are induced by excessive lubrication, or the use of too rich an explosive mixture.

It will be found to be no small task in designing an explosive motor with the usual form of valve construction and operation, to keep the combustion chamber down to the required dimensions and at the same time have it free from bends or contracted passages between the combustion space and the valve chamber.

Many attempts have been made to obviate this difficulty by making the combustion chamber simply a straight extension, or continuation of the cylinder. In this manner both the admission and exhaust-valves can be placed in the cylinder itself and an ideal combustion space secured. This plan has, however, certain disadvantages, from the fact that it not only lengthens the motor, but requires a more complicated form of valve operating mechanism than if the valve chamber were at the side of the cylinder as is usual.

TABLE 9.

PROPERTIES OF COMPRESSED AIR

Comp. in Atmospheres.	*Mean Pressure.	Temp. in Degrees Fah.	*Gauge Pressure.	*Absolute Pressure.	*Isothermal Pressure.
1	0	60	0	14.7	
1.68	7.62	145	10	24.7	30.39
2.02	10.33	178	15	29.7	39.34
2.36	12.62	207	20	34.7	48.91
2.70	14.59	234	25	39.7	59.05
3.04	16.34	252	30	44.7	69.72
3.38	17.92	281	35	49.7	80.87
3.72	19.32	302	40	54.7	92.49
4.06	20.57	324	45	59.7	104.53
4.40	21.69	339	50	64.7	116.99
4.74	22.76	357	55	69.7	129.84
5.08	23.78	375	60	74.7	143.05
5.42	24.75	389	65	79.7	156.64
5.76	25.67	405	70	84.7	170.58
6.10	26.55	420	75	89.7	184.83

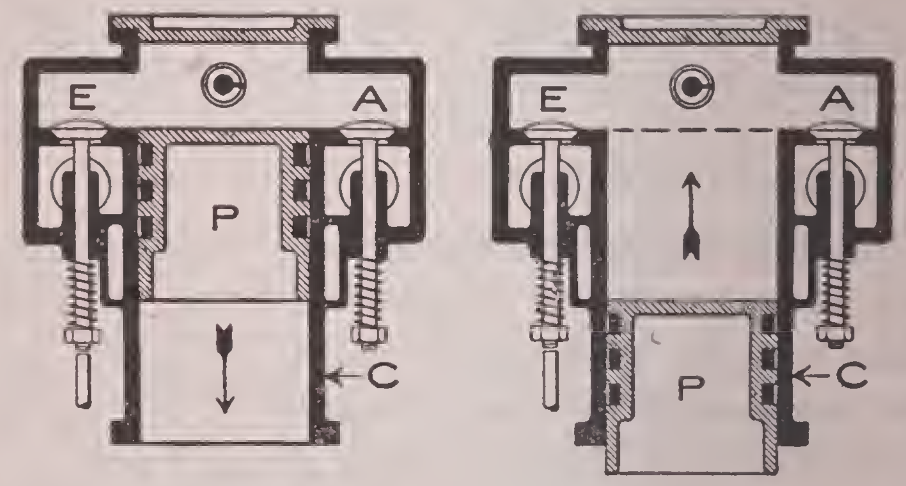
*In pounds per square inch.

AIR PROPERTIES OF COMPRESSED. Table 9 gives the Mean pressure, Temperature in degrees Fahr., Gauge pressure, Absolute pressure and the Isothermal or heat pressure of air under compression of from 1 to 6.10 atmospheres.

As energy in the form of power must be used to compress air to any desired pressure, so is energy in the form of latent or stored heat given up by the air during the operation of compression. This heat consequently increases the pressure resulting from the compression, but not directly in proportion to the degree of compression in atmospheres.

This increase of pressure above the Adiabatic or calculated pressure is known as the Isothermal or heat-pressure. As the values of this pressure cannot be calculated by the use of ordinary mathematics, but involve the use of logarithms, Table 1 gives these values for each degree of compression given.

Many persons who are not familiar with the properties of gases, estimate the pressure resulting from the compression to a given number of atmospheres, as the number of atmospheres multiplied by the atmospheric pressure, which



FOUR-CYCLE MOTOR DIAGRAM

Fig. 130.

at sea level is taken as 14.7 pounds per square inch.

This assumption is erroneous and will often lead to grievous mistakes in motor design, generally giving too much compression, which results in premature ignition, commonly known as backfiring. Such methods of calculation would be true if the air, after compression, was stored in a reservoir and allowed to cool, but under no other conditions.

FOUR-CYCLE MOTOR. Fig. 130 furnishes two sectional views of a four-cycle type of motor with some of the parts removed, as in Fig. 121. It shows a cylinder C, admission-valve A, a piston P, and exhaust-valve E.

The left-hand view shows the piston P about to suck in a charge of vapor, by the same method as previously described, through the admission-valve A into the cylinder C. The suction continues until the piston P reaches the position shown in the right-hand view. Then the piston returns until it again arrives at the position shown in the left-hand view, compressing the charge of mixture during this operation. Just before the piston arrives at the end of its travel in this direction, the charge of vapor, now under compression, is ignited by the method previously explained and its expansion forces the piston back to the position shown in the right-hand view. When the piston has, for the second time, reached the position shown in the right-hand drawing, a mechanical device opens the exhaust-valve. The exhaust-valve remains open until the piston has again arrived at the position in the left-hand view. Then it closes, the piston again commences to draw in a charge of vapor and the cycle of operation of the motor is repeated.

FOUR-CYCLE MOTOR, OPERATION OF. A four-cycle motor has only one working stroke or impulse for each two revolutions. During these two revolutions which complete the cycle of the motor, six operations are performed:

1. Admission of an explosive charge of gas, or gasoline vapor and air to the motor-cylinder.

2. Compression of the explosive charge.

3. Ignition of the compressed charge by a hot tube, or an electric spark.

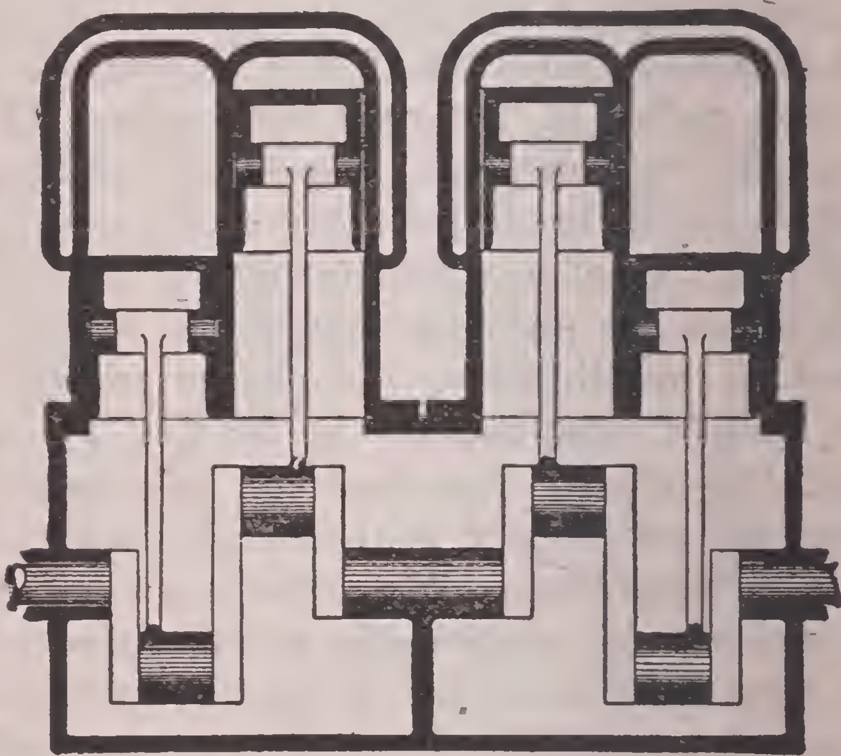


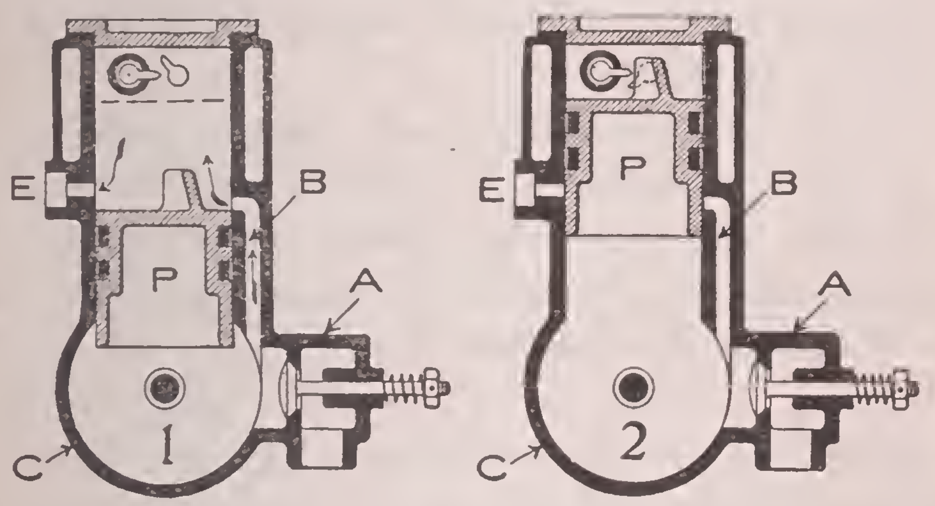
Fig. 131
Four-Cylinder Engine

4. Explosion or extremely sudden rise in the pressure of the compressed charge, from the increase in temperature after ignition.

5. Expansion of the burning charge during the working stroke of the motor-piston.

6. Exhaust or expulsion of the burned gases from the motor-cylinder.

Two-Cycle Motor. The foregoing outline of the functions of the parts of the motor prepares us for a description of the two-cycle form of motor. This particular form of motor draws in a charge of gas or vapor, compresses it, fires it and discharges the product of combustion or burned gases while the crank makes but a sin-



TWO-CYCLE MOTOR DIAGRAM

Fig. 132

gle revolution, and while the piston makes one complete travel backward and forward.

Fig. 132 shows two sectional views—that is to say, views of the motor cut in two, longitudinally—of the principal parts of a two-cycle motor. Other parts, such as the crankshaft, connecting rod and flywheel, are omitted to avoid confusion. C is the crankcase and A the admission valve, through which the vapor passes to the crank case. B is the inlet passage, through which it passes from the crank chamber to the cylinder. P is the piston. The igniter, which makes the electric spark when the lower point comes in contact with the upper, is shown immediately below the cylinder cover. This causes the explosion of the vapor. E is the exhaust port, through which the burned charge escapes after the piston has been driven outward by the explosion and has reached the end of its stroke.

Let it be supposed that the motor is still and the crank chamber C is full of gas or vapor. To start the motor the piston is started by means of a crank on the flywheel shaft, and as it passes to the position shown in the left-hand drawing it forces the charge of vapor through the port B into the cylinder. The piston then returns to the position shown in the right-hand view, moving away from the crank chamber C, and in doing so closes the port B and the exhaust opening E and compresses the charge of vapor. The points of the igniter separate, a spark occurs and the resulting explosion forces the piston outward again. When the piston reaches a point near the end of the stroke, as shown in the left-hand drawing, it uncovers the port E and the burned charge passes out, the new charge coming through the port B immediately afterwards.

The admission of the new charge to the crank chamber is controlled by the action of the piston. As the latter travels outward it has a tendency to create a vacuum in the crank chamber. This draws the valve inward and admits the charge of vapor.

It will be observed that there is a projection on the head of the piston. This is generally known as a baffle-plate. Its object is to prevent the incoming charge from passing directly across the cylinder and out at the exhaust port E, which, it will be observed, is directly opposite it. The baffle-plate directs the incoming charge toward the combustion chamber end of the cylinder, providing as nearly as may be, a pure charge of vapor and assisting in the expulsion of the remainder of the burned gases remaining in the cylinder as a result of the last explosion.

MOTORS—TWO AND THREE PORT. In the two-port motor, as illustrated in Fig. 133, the functions are as follows:

The first stroke of the piston produces a vacuum in the crankcase and the mixture rushes in (as a consequence) through the check valve in the motor case. The second stroke compresses the mixture, and when the communicating port is uncovered the mixture surges into the cylinder. The next (third) stroke compresses the mixture entrapped in the cylinder, since the ports are then covered by the piston, and at the proper instant the mixture is ignited.

From this point on it is a normal repetition of functions, and once the motor gets under way it two cycles. The three-port motor, Fig. 134, differs in that the mixture is taken in through a third port uncovered by the piston, instead of through a check valve in the case, and the details in practice change accordingly.

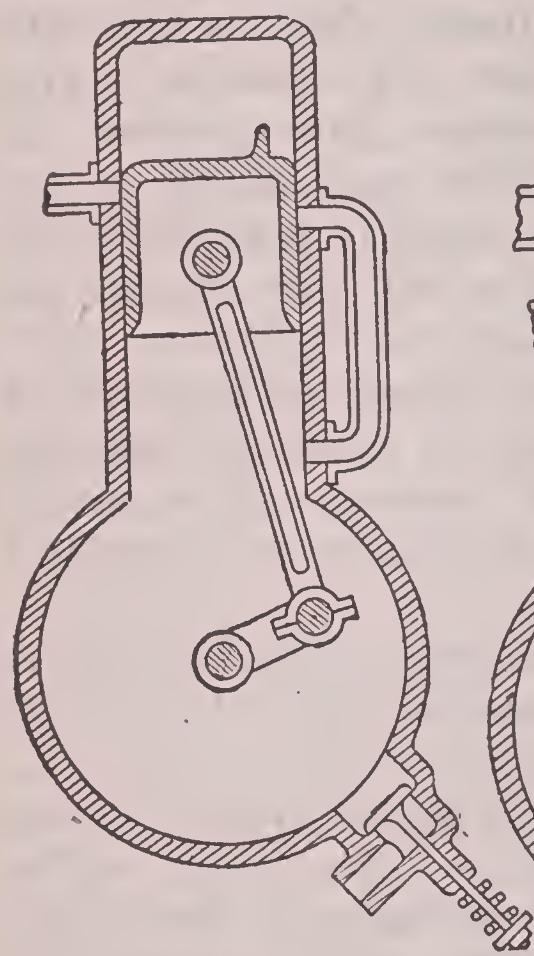


Fig. 133
Two-port Motor

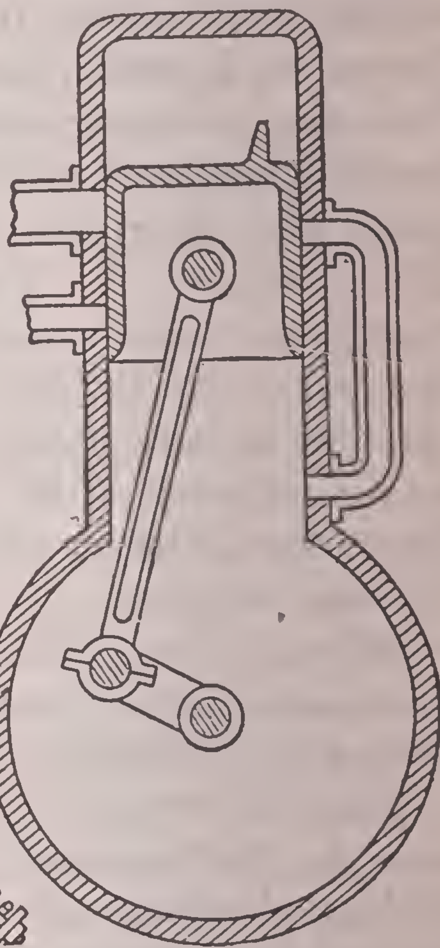


Fig. 134
Three-port Motor

ENGINE, GASOLINE, FUEL CONSUMPTION OF. The fuel consumption of a motor is always a serious question, and one of importance to the purchaser as well as to the manufacturer.

Ordinarily about one and two-tenths pints of gasoline per horsepower hour under full load will cover the fuel consumption. That is, when the mixture is of the proper explosive quality and the water comes from the jacket at a temperature of about 160 degrees Fahrenheit.

The temperature of the water in the jacket around the cylinder has a great deal to do with the fuel consumption.

If the water is forced around the cylinder so as to keep it cold, the heat from the combustion is cooled down so quickly by radiation that the expansive force of the burning gases is materially reduced, and consequently less power is given up by the motor.

The object of the water is not to keep the cylinder cold, but simply cool enough to prevent the lubricating oil from burning. The hotter the cylinder with effective lubrication the more power the motor will develop.

Engine, Two-Cycle, Fuel Consumption of. The two-cycle engine uses more fuel than the four-cycle. The greatest consumption is not so much due to the fact that the two-cycle motor makes an explosion for every revolution, in contrast with the missed stroke of the four-cycle, as it is to the fact that there is a considerable retention in the cylinder of the exhaust charge, and that, despite the deflector, more or less of the fresh charge escapes at the exhaust. The two-cycle is also harder on a battery owing to the greater frequency of the demands upon it, but with improved methods of ignition, even dry batteries have been found to give very satisfactory service.

Engine, Sliding Sleeve Type. The Knight sleeve valve engine, Fig. 135, is a four cycle gasoline engine in which the usual poppett valves have been replaced by two concentric sleeves sliding up and down between the cylinder walls and the piston. Certain slots in these sleeves register with one another at proper intervals, producing openings between the combustion chamber and the inlet and exhaust

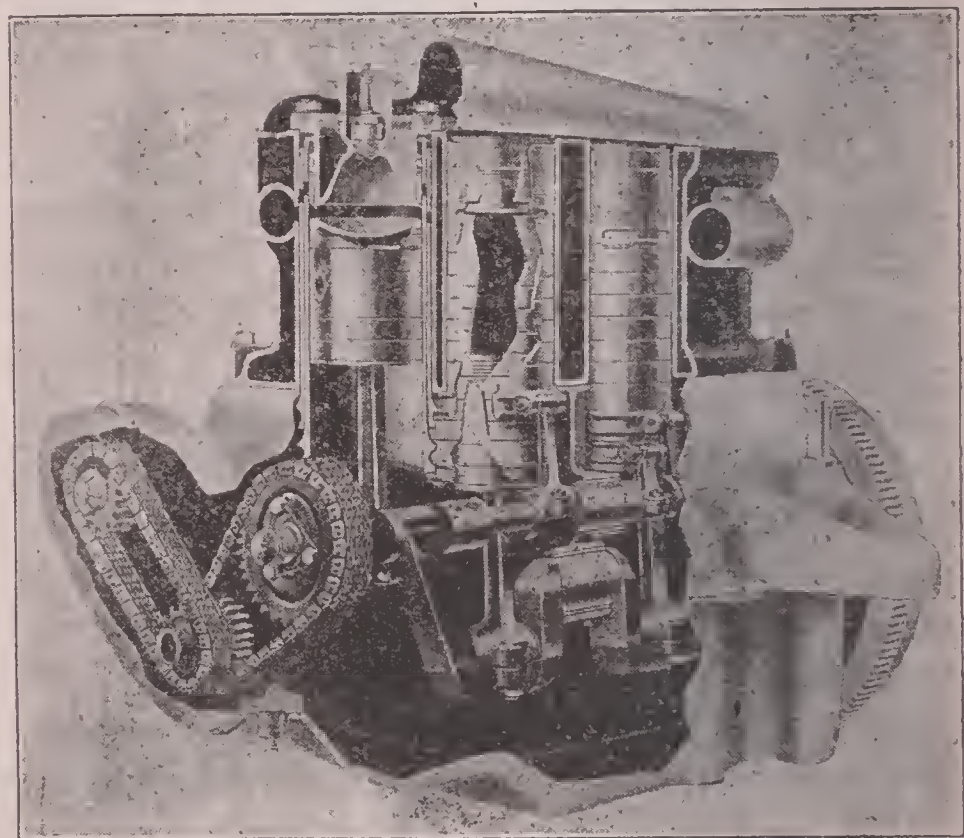


Fig. 135
Knight Sliding Sleeve Engine

manifolds for the passage of fresh gas into the cylinder and burned gas from it.

It will be noted that the two sleeves are independently operated by small connecting rods working from a shaft made with eccentrics. This eccentric shaft is driven at one-half crankshaft speed, usually by silent chains. This shaft takes the place of, and performs the same

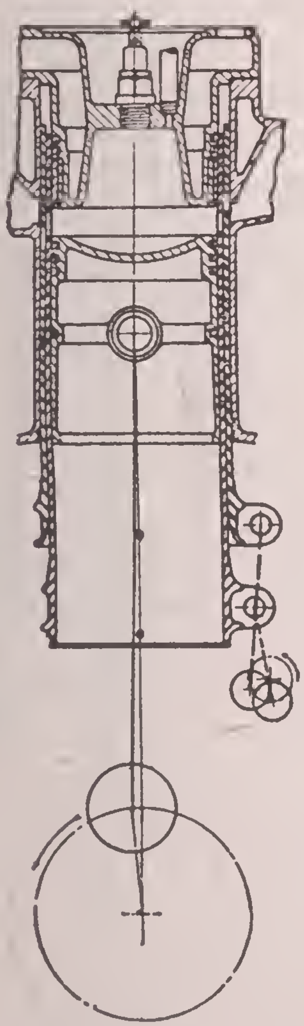


Fig. 136

Inlet Opening on Knight Engine

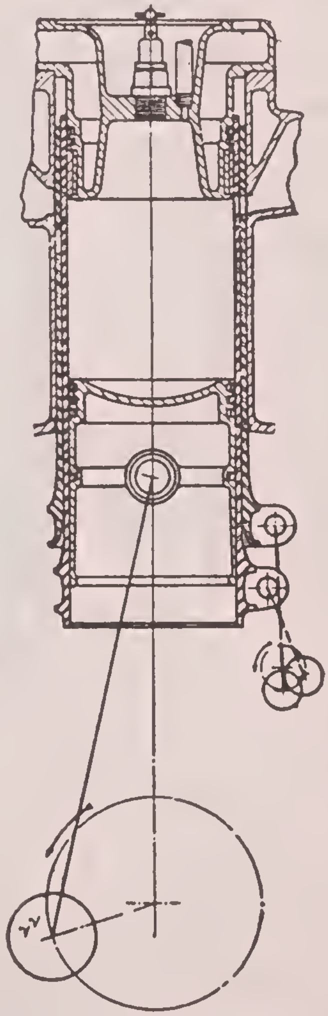


Fig. 137

Inlet Open on Knight Engine

functions as the camshaft in the poppett valve engine. The eccentric pins that operate the inner sleeves are given a certain advance or lead over those operating the outer sleeves. This lead, about 90 degrees, together with the half-speed rotation of the shaft, gives the following valve action:

In Figs. 136 to 142 the relative positions of the pistons, sleeves and ports are shown in

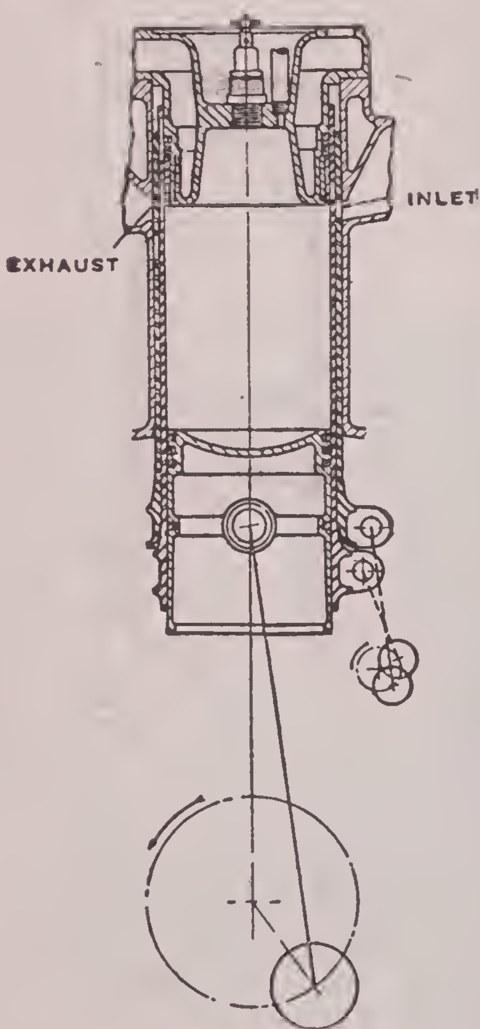


Fig. 138
Inlet Closing

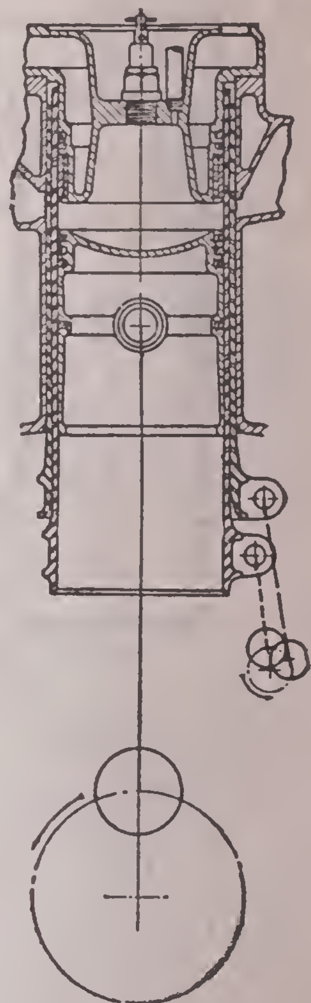


Fig. 139
Firing Point

various positions during the two revolutions of the crankshaft that make up one working cycle of inlet, compression, power and exhaust strokes. Fig. 136 shows the inlet just opening. The port, or slot in the inner sleeve is coming up, the port in the outer sleeve is going down and the passage for the incoming gas is formed by the rapidly increasing opening between the upper edge of the slot in the inner sleeve and the lower edge of the slot in the outer sleeve.

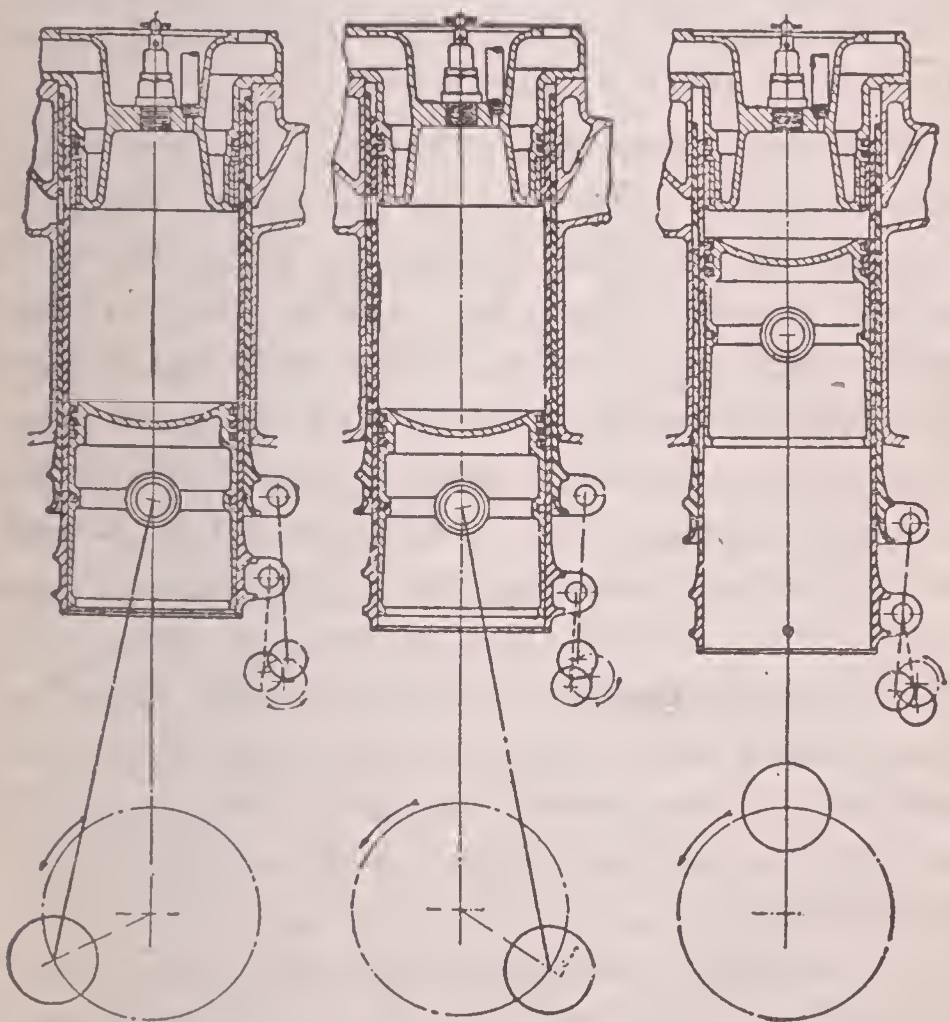


Fig. 140 Exhaust Opening Fig. 141 Exhaust Open Fig. 142 Exhaust Closing

Fig. 137 shows the inlet fully open. The inner and outer slots are exactly opposite each other and the inlet opening in the cylinder wall. Fig. 138 shows the closing of the inlet. The cylinder has been filled with fresh mixture and is ready for the compression stroke. Fig. 139 shows the position of the sleeves at the top of the compression stroke; the combustion space having been completely sealed by the expansion rings in the cylinder head above and in the piston below. The firing of the mixture takes place at this point.

Fig. 140 shows the exhaust port just starting to open. The slot in the outer sleeve is coming up and the slot in the inner sleeve is going down. Fig. 141 shows the exhaust ports fully open. The inner and outer slots are opposite each other and at the same time opposite the cylinder opening that leads to the exhaust piping. Fig. 142 shows the closing of the exhaust opening and is practically identical with the position shown in Fig. 136. The four strokes of the cycle (inlet, compression, power and exhaust) have now been completed, the crankshaft has made two complete revolutions and each sleeve has moved up and down once.

The timing of inlet and exhaust opening and closing is not different from that ordinarily used in poppett-valve engines, but the opening secured with this construction is greater than that ordinarily found in the poppett type. Some advantage is also gained because of the more direct path of the incoming and outgoing gases. The timing of the valve openings is not affected by spring pressure or engine speed.

ENGINES, EIGHT AND TWELVE CYLINDER TYPES. The development of the automobile engine has been along the lines of increase in number of cylinders and decrease in the size of the individual cylinders, without any considerable increase in the total horsepower delivered by the engine. This development has resulted in the power being delivered more evenly, inasmuch as an impulse is delivered to the crankshaft each time a cylinder fires. With the single cylinder engine, one impulse was given for each two revolutions and with the increase to four, six and eight cylinders, the crankshaft has received two, three and four impulses for each single revolution. The twelve cylinder secures a power stroke for each sixty degrees revolution of the crankshaft and consequently gives six impulses for each revolution.

The most radical change between former types of engine and the eight and twelve cylinder types is that of placing the cylinders in two equal divisions, and, in place of standing vertically, they are placed at an angle of ninety degrees in the eight and sixty degrees in the twelve. This design does not materially increase the length of the engine over one having four or six cylinders of equal size and, of course, makes the height somewhat less, due to the inclination. While these engines naturally require additional cylinders, valves, connecting rods and pistons, they make use of only one

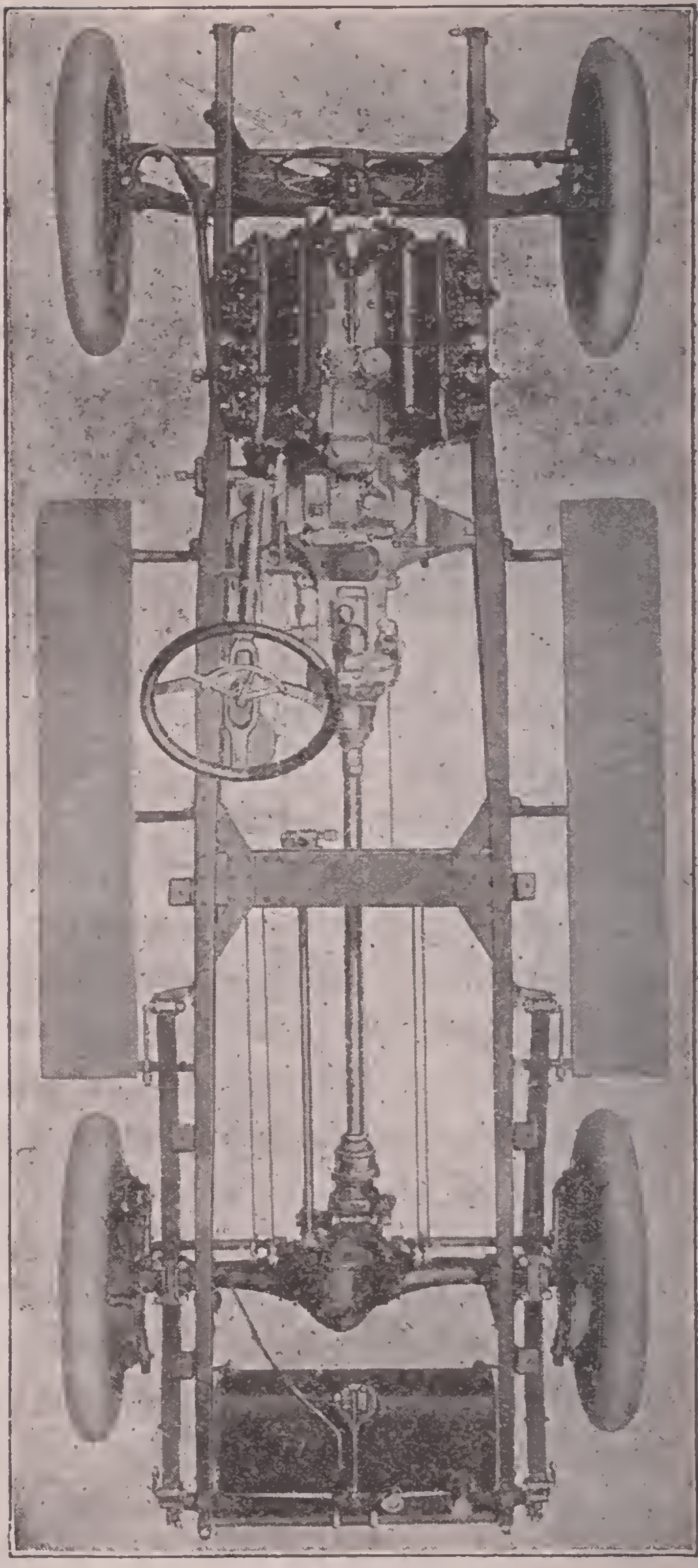


Fig. 143
Eight Cylinder Chassis

crankshaft and generally of but one camshaft. No other increase in number of parts or accessories is necessary, one carburetor, one ignition device and one of each of the other power-plant units doing the work for both sets of cylinders.

The mounting and construction of the generally accepted type of eight cylinder engine is shown in Figs. 143 to 145. As will be noted from the top view shown in Fig. 143, a space is left between the cylinder blocks which provides suitable location for such fittings as the carburetor, the ignition unit and usually the lighting dynamo. The valves are located on the inside of their respective castings and the resulting position of the caps allows easy removal, inspection and grinding.

The center lines of the two cylinder blocks intersect at the center of the crankshaft, and, as will be noted from the side elevation in Fig. 144, the crankshaft itself does not differ from the usual four-throw type used with four cylinder engines. Depending on the type of connecting rod construction used, the cylinders in the blocks are set so that corresponding ones on opposite sides are exactly opposite or slightly offset from each other in a lengthwise direction. In any case the connecting rods from the two front cylinders fasten to one crankpin, while those from the second cylinders are on the next crankpin, and so on for those remaining.

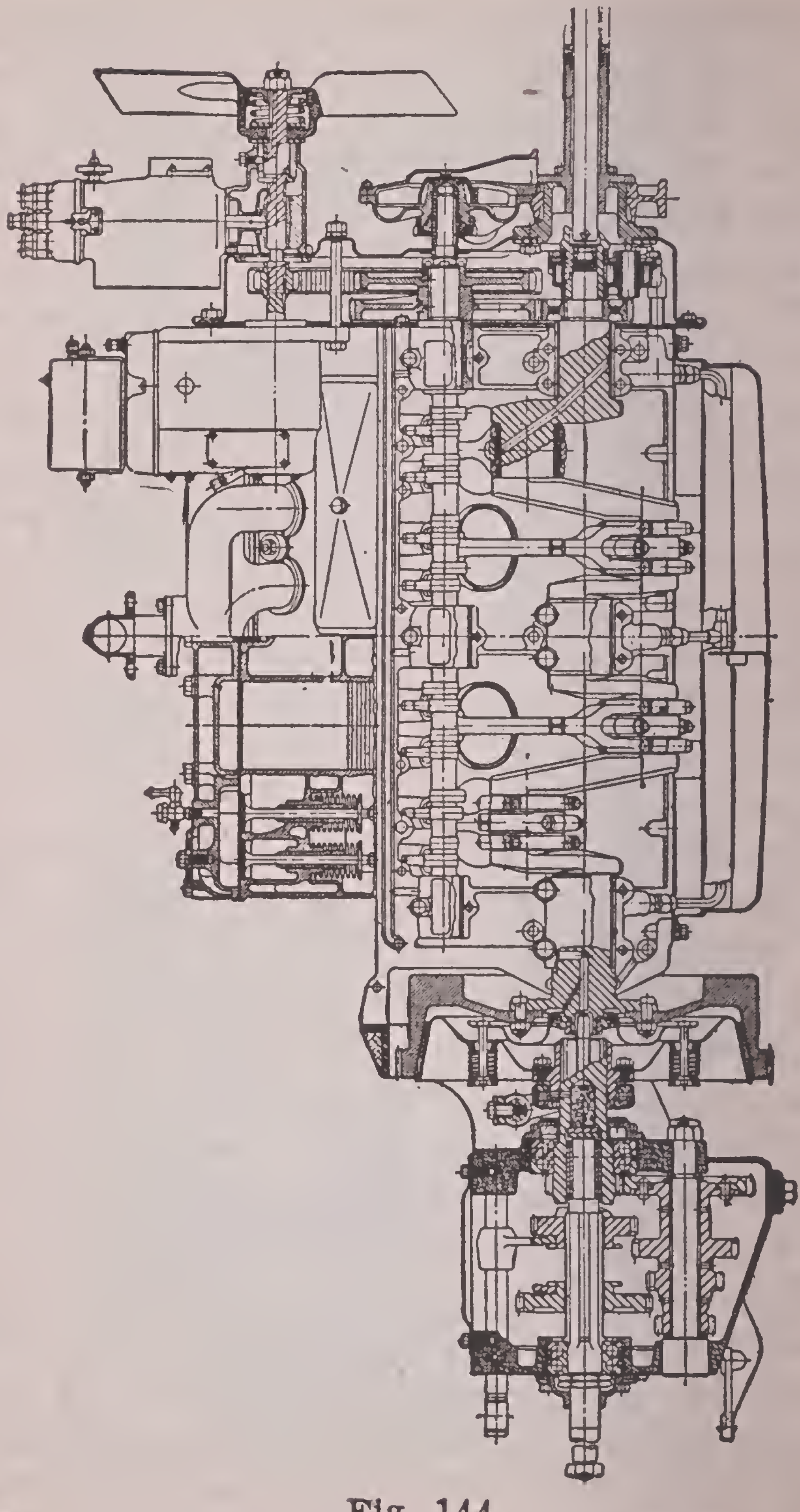


Fig. 144
Side View of Eight Cylinder "V" Type Engine

Three types of construction are in use for the lower end of the connecting rods; the most commonly used method being shown in Figs. 144 and 145, in which one rod is straight and of

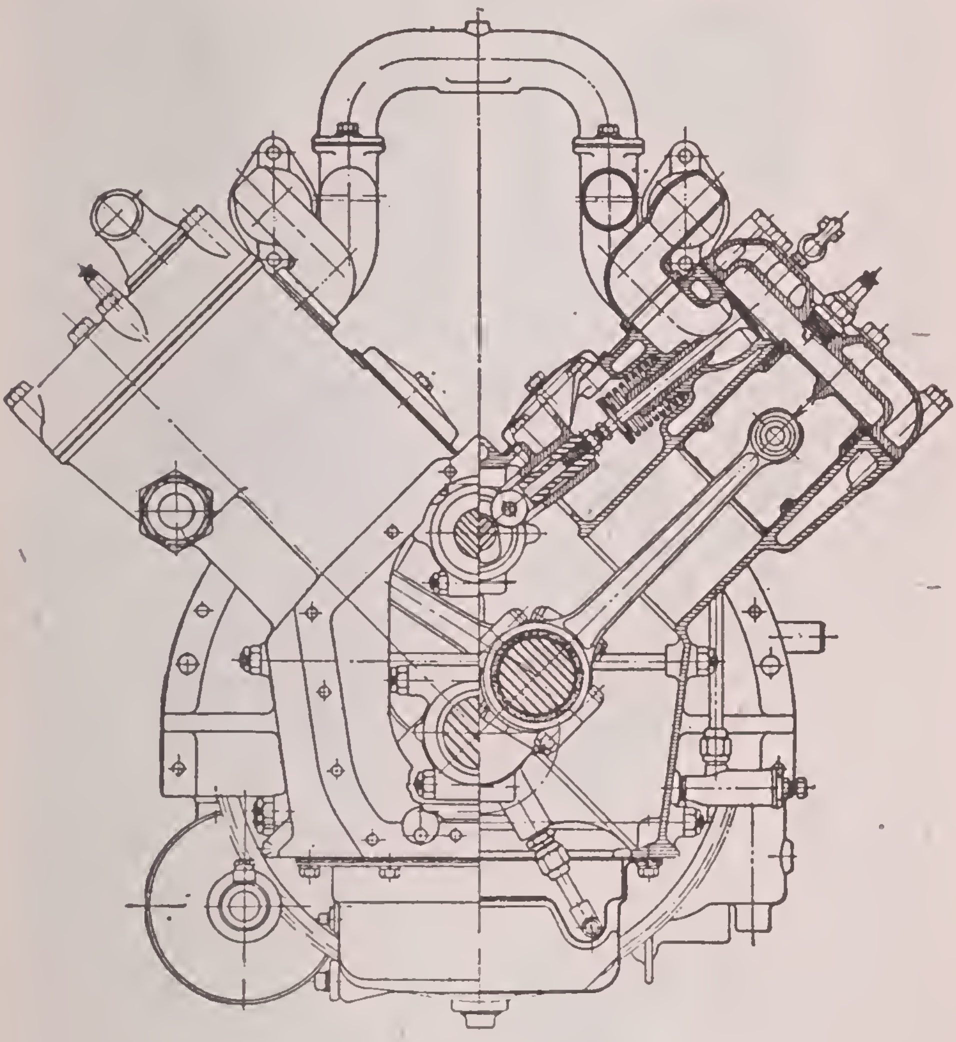


Fig. 145
End View of Eight Cylinder Engine

the usual pattern while the corresponding one is forked and has the two sides of the fork so placed that they are on either side of the straight member. With this construction, the crankpin is surrounded with a sleeve or liner of bearing metal and the forked rod is clamped

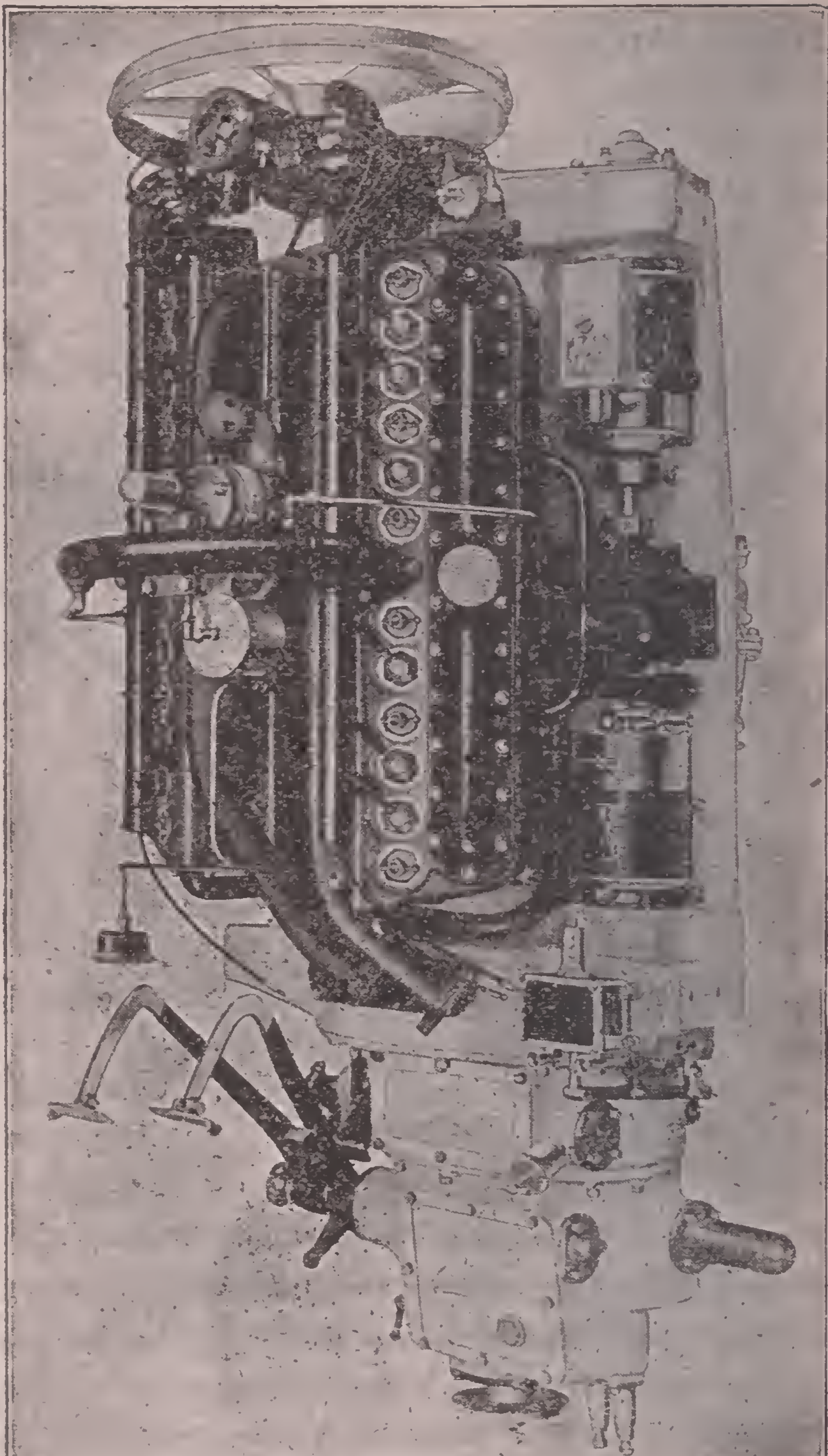


Fig. 146
Packard Twelve Cylinder Engine

around this liner so that the liner is held tightly by the rod, and the shaft turns inside the liner. The end of the straight connecting rod has its bearing on the outside of the liner just mentioned and therefore has only a reciprocating motion on the liner in place of turning all the way around. The bearing of the straight rod on the liner is adjustable, but the liner is not adjustable on the crankshaft.

Another form of connecting-rod construction forms one of the rods in the usual way with an adjustable bearing on the crankpin. On the big end of the rod just mentioned is a boss that carries a pin similar to a wristpin, and on this pin is mounted the bearing of the second connecting rod. The end of the second rod does not surround the crankshaft but is mounted on the end of the one with the bearing.

The third form of rod construction is little used on eight cylinder types, but is quite common on twelves. This method uses a complete rod end and bearing on each rod, the ends and liners being placed side by side so that each connecting rod has a bearing on one-half of the length of the crankpin. The rods are not in the same plane and therefore the cylinders are offset, the set on one side of the engine being a little forward or back of the opposite set. This method allows individual adjustment of each bearing.

In engines with either eight or twelve cylinders, the camshaft is mounted directly above the crankshaft and therefore between the cylinder blocks. Two designs are in common use, one making use of separate cams for each of the sixteen or twenty-four valves, and the other using but one cam for the inlet valves of opposite cylinders and another cam for the corresponding exhaust valves. With but one cam for two valves, the valve plunger rollers do not rest directly on the cam, but the plungers are operated from rocker arms, hinged at one end to the crankcase and having a roller at the end that rests on the cam. When individual cams are used for each valve, the cams are of necessity placed side by side, but the slight distance between each pair makes it necessary to offset the valves or offset the cylinder blocks in a lengthwise direction.

As mentioned, it is customary to use one carburetor with a manifold that divides near the instrument with one branch for each cylinder block. Some difficulty was met with in providing suitable ignition for engines with eight or twelve cylinders, but this has been overcome by improved forms of ignition breakers, by the use of two distributors and two breakers in some cases and by the adoption of new principles of magneto construction in others. When it is realized that a twelve cylinder engine running at 1,800 revolutions a minute (a moderate speed) requires 10,800 accurately timed and powerful sparks every minute, the reason for the difficulty will be seen.

In considering the firing order of these engines, it should be borne in mind that an eight is similar to two four cylinder engines, side by side, while a twelve is similar to two sixes. All four cylinder engines fire in one of two orders, either 1-3-4-2 or else 1-2-4-3, considering the front cylinder as number one. Each set of four cylinders in an eight, that is, the left hand set and the right hand set fires in one of these orders, the only difference with the eight being that one of the cylinders of the left hand set fires just half way between two on the right, while each cylinder on the right fires midway between two on the left. The cylinders on the left, from front to back are usually designated as No. 1 Left, No. 2 Left, and so on; while those in the right are No. 1 Right, No. 2 Right, etc. The firing order of a number of eight cylinder engines is therefore as follows: 1L, 4R, 3L, 2R, 4L, 1R, 2L, 3R; in which it will be seen that, looking at either the "Ls" or "Rs," they fire 1-3-4-2.

The principles explained above apply equally to the twelve, in which the engine may be considered as two sixes, each set of cylinders firing in one of the orders possible for a six. It is possible to number all the cylinders in either an eight or twelve cylinder engine consecutively from 1 up and in this case the front right hand cylinder is usually called number one. The numbering may then continue from front to back on the right hand side, in which case these cylinders will be numbered from 1 to 6, or may pass to the left side, calling the left

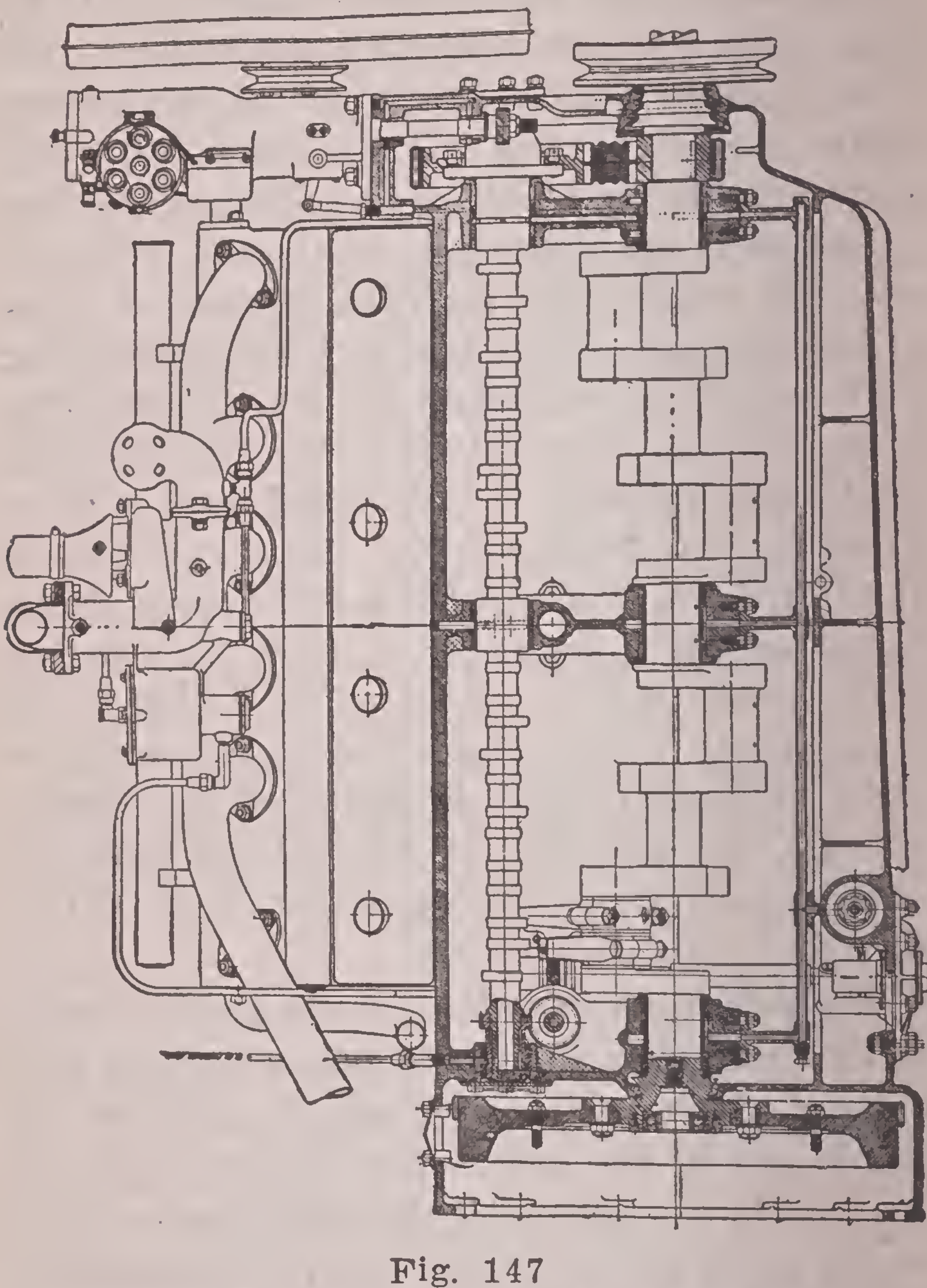


Fig. 147
Section Through Twelve Cylinder Engine

front cylinder No. 2, the second one on the right No. 3, etc. This last method would bring all the odd numbers on the left and all the even numbers on the right.

Designating the cylinders of a twelve by the numbers 1 to 6 and showing their position by letters, a common firing order would be as follows: 1R, 6L, 5R, 2L, 3R, 4L, 6R, 1L, 2R, 5L, 4R, 3L. This fires each set in the common order: 1-5-3-6-2-4.

A twelve cylinder engine is shown in Figs. 146 and 147, and most of the data given in the foregoing pages applies equally to the twelve and the eight. The principal difference between the two types is that the angle included between the cylinder blocks of the twelve is less than that of the eight, thus leaving less space between the blocks in the location often called the "valve alley." Because of the smaller space between the cylinders, a larger one is left outside of the cylinders before the sides of the hood are reached. This fact has led to the practice on twelves of locating the accessories, with the exception of the carburetor, outside of the cylinder blocks and in the same place that they usually occupy on four and six cylinder types.

Exhaust—Cause of Smoky. Smoke coming from the exhaust of a gasoline motor is due to one of two conditions: Over-lubrication—too much lubricating oil being fed to the cylinder of the motor– or too rich a mixture, that is, too much gasoline and an insufficient supply of air.

The first condition may be readily detected by the smell of burned oil and a yellowish smoke. The second, by a dense black smoke accompanied by a pungent odor.

Expansion—Best Conditions for. The efficiency of the expansion in an engine cylinder depends upon the initial volume of the charge, the condition of the mixture, the compression pressure, the point of ignition, the speed of expansion and the losses due to radiation.

The losses due to improper expansion may therefore be decreased by making large valves and valve passages, but these often mean greater heat losses. The losses due to radiation may be reduced by increasing the temperature of the jacket water, and decreasing the area of the cylinder. But if the cylinder wall temperature is increased, there are considerable difficulties with lubrication, and the increased gain in thermal efficiency will be more than offset by the increased friction.

In order to obtain the highest efficiency the difference in the temperature of the water entering and leaving the cylinder jacket should be a maximum. In practical tests it has been found that the best results are obtained when the jacket water is near the boiling point.

Frames. The frame of passenger cars is made, in practically all cases, from sheet steel ranging in thickness from ⅛ to ⅜ inch and pressed, either while hot or cold, into a channel section. This type of frame is called pressed steel. In rare cases the steel channel is reinforced with pieces of wood, while in other constructions the body of the frame is made from wood and is then reinforced with plates or channels of steel.

Commercial car and truck frames are also made from pressed steel in a majority of cases. Other constructions employ rolled steel of channel "I" beam section, these shapes being bent to the required forms to suit the general design of the car.

Pressed steel frames are made from carbon or special alloy steels, either in the natural condition or heat treated. The Society of Automotive Engineers recommends a choice between three grades of steel for pleasure car frames; the first being a .15 to .25 point carbon without heat treatment and having an elastic limit of 35,000 pounds per square inch. The second is a steel of .20 to .30 point carbon, having in the natural state an elastic limit of 40,000 pounds, and when heat treated a limit of 60,000 pounds to the inch. The third material is a chrome-nickel steel of .25 to .35 point carbon, which is heat treated and has an elastic limit of 85,000 pounds per square inch.

The frame is usually designated as to size by giving the measurement of the outside depth. Frames 3 or 3½ inches deep are usually made ⅛ inch thick; frames 4 inches deep are made 5/32 inch thick, those 4½ to 6 inches deep are either $\frac{3}{16}$ inch or ¼ inch thick; all of the above being for passenger cars. Should the thickness vary from the measurements just given, the depth dimension will be changed from the nominal size. The width of the flange is never less than 1½ inches for frames up to 4½ inches deep and not less than 1¾ inches for deeper frames.

The dimension called the drop is measured from the top of the side member to the center of the front spring bolt hole. The rear end rise, often called the "kick-up," ranges from 2 to 5 inches. A side rail offset is employed to allow short turning of the steering wheels, the distance back of the front taper that this offset commences, being at least 10 inches.

The frame is completed with a number of cross members joining the side rails, these cross members being suited in number, size and shape to the general design of the car. In some cases the power plant is carried upon a small sub-frame supported inside of the front portion of the main frame, this sub-frame consisting of two lengthwise rails carried by two cross members, one at the front and the other at the rear of the sub-frame.

Friction. Friction, being the resistance to motion of two bodies in contact, depends upon the following laws: It will vary in proportion to the pressure on the surfaces; friction of rest is greater than friction of motion; the total friction is independent of the area of the contact surfaces when the pressure and speed remain constant; and friction is greater between soft bodies than hard ones.

The behavior of lubricated surfaces is quite different from dry ones, the laws of fluid friction being independent of the pressure between the surfaces in contact, but it is proportional to the density of the fluid and in some manner to the viscosity. When a bearing is thoroughly lubricated it does not seem to make much difference what the metals are, because there is a layer of oil running around with the journal and sliding over another layer adhering to the bearing. If, however, the feed fails, or the pressure gets too heavy for the nature of the lubricant, and so squeezes it out, or the temperature has risen so high as to affect the body of the oil, then the surfaces come into contact and the peculiar nature of the contact asserts itself, some combinations abrading and seizing more readily than others. When the lubrication is thorough, the condition of the fluid friction being realized, the intensity of the load makes less difference than would be expected.

Fuels for Automobiles. Apart from the possibility of an increase in the fuel resources of the world due to some revolutionary discovery, the ingredients in any mixed fuel for automobile use must be confined to the following list, in which, for completeness, gasoline is included:

Gasoline. Average composition, C=84, H=16.

Source, petroleum.

Boiling point, 50° to 150° Cent.

Specific gravity, .680 to .720.

Calorific value, 19,000 B. T. U.

Latent heat, small.

Benzine. Average composition, C=92, H=8.

Source, coal tar.

Boiling point, 80° Cent.

Freezing point, 5° Cent.

Specific gravity, .899.

Calorific value, 19,000 B. T. U.

Latent heat, small.

Alcohol. Average composition, C=32, H=8, O=35.

Source, vegetable matter, principally corn, beets, potatoes, sugar cane.

Boiling point, 70° Cent.

Specific gravity, .806.

Calorific value, 12,600 B. T. U.

Latent heat, considerable.

Tar Benzol. Average composition, C=92, H=8.

Source, a by-product in the manufacture of coke.

Boiling point, 80° to 120° Cent.

Specific gravity, .895.

Calorific value, 19,000 B. T. U.

Latent heat, small.

Kerosene. Average composition, C=85, H=15.

Source, petroleum.

Boiling point, 150° to 300° Cent.

Specific gravity, .800 to .825.

Calorific value, 19,000 B. T. U.

Latent heat, considerable.

Motor Spirit, Naphtha, Benzoline, Benzine. Average compositnon, C=85, H=15.

Source, petroleum and shale.

Boiling point, 60° to 160° Cent.

Specific gravity, .750.

Calorific value, 19,000 B. T. U.

Latent heat, appreciable.

Methyl Alcohol; Wood Spirit, Naphtha. Average composition, C=38, H=12, O=50.

Source, the distillation of wood.

Boiling point, 66° Cent.

Specific gravity, .812.

Calorific value, 9,600 B. T. U.

Latent heat, appreciable.

Acetylene Ethene. Average composition, C=92, H=8.

Calorific value, 25,000 B. T. U.

Fuel Mixture. The fuel finally used in the cylinders of the internal combustion automobile engine is composed of varying proportions of air and the vapor of one or more of the liquid fuels. The pure vapor of any of these liquids does not form a combustible mixture until mixed with certain proportions of air, the oxygen necessary for burning being thereby supplied. It is the function of the carburetor to vaporize the liquid fuel and to then mix with the vapor an amount of air which will make a correct mixture.

Many of the questions and problems entering into the question of securing correct mixtures from present day fuels are of vital interest because of the important bearing this feature has upon operating costs. In the following pages is given much of the information which is necessary in studying the relations of the fuel vapors to the air in the mixture, also a number of tables of data pertaining to the heating values and characteristics of the vapors and gases in common use for this purpose.

Air, Relation of to Gasoline. Owing to the fact that automobile gasoline is composed of various percentages of the several available fractions of hydrocarbon distillates, it is not possible to fix an exact basis for the relative proportions of air to fuel. However, the average carbureter is capable of altering the ratio of air to fuel over broad ranges, and it is not necessary to know the exact ratio in order to attain the best results. But it is necessary to approximate an average ratio as nearly as possible in designing and adjusting carbureters in order to allow for these variations up and down.

The mixture becomes explosive when 10,000 volumes of air dilute one volume of gasoline, but the best results follow when the ratio is one volume of liquid gasoline to 8,000 volumes of air. With one of gasoline to 3,500 of air the mixture is non-explosive.

The proper proportions, from a theoretical standpoint, are not always best for practical use because a mixture slightly weaker than the one found by calculation is more economical in the use of gasoline. Such a mixture, of course, reduces the power slightly, but the proportion of power lost is much less than the proportion of gasoline saved. Because of the differences in speed of the mixture and the differences in the volume being admitted to the engine, it is almost impossible to secure a proportion that will be uniformly satisfactory over a range of all engine speeds. A larger volume of mixture, at a slow speed, may be required in ascending a hill at ten miles per hour than in traveling on a level road at three times this speed. In the latter case, the velocity of the mixture will, however, be much greater. It is best to secure a mixture that will give satisfactory results from the standpoint of power at low and medium speeds rather than at high.

Air, Relation of in Gasoline Mixture. Gasoline is a somewhat uncertain mechanical mixture of several hydrocarbon (fractional) distillates, in which the compound "hexane" is supposed to be the major portion. This compound answers to the formula $C_6 H_{14}$, the products of combustion of which will be $CO_2 + CO + H_2O$, in which CO will not be found if the combustion is complete. A final expression of complete combustion will be as follows:

$$2 C_6 H_{14} \times 19 O_2 = 12 CO_2 + 14 H_2 O.$$

Taking into account the atomic weight of the elements, the volume of air required in the complete combustion of 1 pound of hexane may be set down as follows—atomic weight of the elements involved:

Carbon (C)	12
Hydrogen (H)	1
Oxygen (O)	16

The molecular weight of $C_6 H_{14} = 6 \times 12 + 14 \times 1 = 86$; the required oxygen will weigh (molecular) $19 \times 16 = 304$; the ratio of the compound hexane, then, to the combining oxygen will be

$$\text{Ratio} = \frac{304}{86} = 3.54, \text{ nearly.}$$

Considering 1 pound of hexane, the weight of oxygen required for its complete combustion will be equal to the ratio as above given, i.e., 3.54 pounds, nearly.

Since the oxygen is taken from the air, it is necessary to consider dry air in the attempt to determine as to the weight of the same. This air, under a pressure of 1 atmosphere, and at a temperature of 60 degrees Fahrenheit contains 0.23 pounds of oxygen, hence the required air=

$$\frac{3.54}{.23} = 15.39, \text{ in pounds.}$$

GASOLINE, THERMO-DYNAMIC PROPERTIES OF GASOLINE AND AIR. The following table, 10, gives the thermo-dynamic properties of gasoline and air, and may be of interest, in view of the fact that information on this subject is sparse, and most of that only theoretical, or empirical deductions.

This table gives the explosive force in pounds per square inch of mixtures of gasoline vapor and air, varying from 1 to 13 down to 1 to 4, also the lapse of time between the point of ignition and the highest pressure in pounds per square inch attained by the expanding charge of mixture. The tests from which the results given were obtained, were made with a charge of mixture at atmospheric pressure, so as to more accurately note the results, as the mixture takes much longer after ignition to attain its highest pressure, and is slower also in expanding.

It may be well to remember that there are no more heat-units, and consequently no more foot-pounds of work in a mixture of gasoline and air, under 5 atmospheres compression, than under 1 atmosphere compression.

Flanged or ribbed air-cooled motors will approach the figures given in the table for the initial explosive force for the varying compressions, very closely, while thermal-siphon water-cooled motors will come within about 20 per cent of these results, and pump and radiating coil cooled motors will come within about 30 per cent. While it appears that the proper thing to do would be to run hot, the repair bill will more than offset its efficiency. The last two columns in the table give the temperature of the burning gases, the first of the two columns the actual temperature with the accompanying mixture of gasoline and air, and the second the theoretical temperatures, or temperature to which the burning mixture should attain, if there were no heat losses.

TABLE 10.

THERMO-DYNAMIC PROPERTIES OF GASOLINE AND AIR.

Gasoline, Vapor and Air.	Time in Seconds between Ignition and Highest Pressure.*	Explosive Force in Pounds per sq. in. Compression in Atmospheres.			Temperature of Combustion in Degrees Fahrenheit.*	
		3	4	5	Actual.	Theoretical.
1 to 13	0.28	156	208	260	1857	3542
1 to 11	0.18	183	244	305	2196	4010
1 to 9	0.13	234	312	390	2803	4806
1 to 7	0.07	261	348	435	3119	6001
1 to 5	0.05	270	360	450	3226	6854
1 to 4	0.07	240	320	400	2965	5517

*At atmospheric pressure.

Heat of Combustion. The quantity of heat generated by the complete combustion of various gases and petroleum products is known as the heat value of the fuel, and represents the maximum amount of heat that can be obtained from a given quantity of the fuel. No accurate rule has yet been devised by which to compute the heat value of any chemical compound from its formula and the heat values of the elements of which it is composed. Hence, the heat values of compounds must be found by a separate determination for each one in the laboratory. The heat developed by the combustion of some of the commoner fuels and gases is given in Table 11. In the case of carbon, the heat developed by its complete combustion, forming CO_2, and the heat of its partial combustion to CO, are given; also the heat of combustion of CO to CO_2.

Heat Value of a Mixture. The heat value of a mixture may be found from the heat values of the substances of which it is composed and the percentage of each substance. If h_1, h_2, h_3, etc., represent the heat values of the substances forming the mixture, and p_1, p_2, p_3, etc. represent the percentage of each substance, the heat value of the mixture will be represented by the following formula:

$$hm = p_1h_1 + p_2h_2 + p_3h_3 + \text{etc.}$$

Example.—A certain gas has the following composition:

TABLE 11.

MIXTURES OF AIR AND GASES, AND RESULTING HEAT OF COMBUSTION.

Fuel	Chemical Proportions	Weight of Gas at 30°, per Cubic Foot	Volume of 1 Pound of Gas at Atmospheric Pressure Cubic Feet		Volume Required to Burn 1 Cubic Foot of Gas Cubic Feet		Weight Required to Burn 1 Pound of Gas Pounds		Specific Heat of Gas at Constant Pressure	Heat of Combustion	
		Pound	32°	62°	O	Air	O	Air		B. T. U. per Pound of Fuel	B. T. U. per Cubic Foot of Gas at 62°
Oxygen, O	23 lb.O + 77 lb.N = 100 lb. air	.08927	11.20	11.88	...	.....	....	.....	.21751	......	.....
Nitrogen, N	21 vol.O + 79 vol.N = 100 vol. air	.07847	12.77	13.55	...	.....	....	.....	.24380	......	.....
Hydrogen, H	2H + O = H_2O	.00562	178.80	189.80	.5	2.38	8.00	34.80	3.40900	62,000	327
Carbon, C	C + O = CO	......	......	......	...	.....	....	.....	....	4,400	.....
Carbon, C	C + 2O = CO_2	......	......	......	...	.....	....	.....	....	14,600	.....
Carbon monoxide, CO	CO + O = CO_2	.07704	12.77	13.55	.5	2.38	.57	2.48	.24790	4,385	324
Carbon dioxide, CO_2	1 lb.C + 2.66 lb.O = 3.66 lb. CO_2	.12323	8.12	8.60	...	.....	....	.....	.21700	......	.....
Methane, CH_4	CH_4 + 4O = $2H_2O$ + CO_2	.04538	22.37	23.73	2.0	9.52	4.00	17.40	.59290	23,976	1,010
Ethylene, C_2H_4	C_2H_4 + 6O = $2H_2O$ + $2CO_2$	.07830	12.77	13.55	3.0	14.28	3.43	14.90	.40400	21,476	1,585
Ethane, C_2H_6	C_2H_6 + 7O = $3H_2O$ + $2CO_2$	.08369	11.94	12.67	3.5	16.66	....	.....	....	22,356	1,765
Benzol vapors, C_6H_6	C_6H_6 + 15O = $3H_2O$ + $6CO_2$	.22363	4.47	4.74	7.5	35.7	....	.....	.37540	18,183	3,836
Acetylene, C_2H_2	C_2H_2 + 5O = H_2O + $2CO_2$	.07251	13.79	14.63	2.5	11.9	....	.....	....	21,421	1,464

Constituents of Gas	Per Cent.
Hydrogen, H	20
Marsh gas, CH_4........................	70
Acetylene, C_2H_2	10

What is the heat value per cubic foot of the mixture?

Solution.—Referring to Table **11**, the heat values per cubic foot of these gases are seen to be 327, 1,010 and 1,464 B. T. U., respectively. Apply the formula just given. $p_1 = .20$, $p_2 = .70$, and $p_3 = .10$. Also, $h_1 = 327$, $h_2 = 1{,}010$, and $h_3 = 1{,}464$. Substituting, $hm = .20 \times 327 + .70 \times 1{,}010 + .10 \times 1{,}464 = 65.4 + 707 + 146.4 = 918.8$ B. T. U. Ans.

Temperature of Combustion. The theoretical temperature of the combustion of a given fuel can easily be calculated. Making no allowance for losses of heat, and supposing that just enough air is furnished for the combustion, burning carbon should have a temperature about 4,940° above zero; while burning hydrogen should have a temperature about 5,800° above zero. In practice, these temperatures are never attained, on account of heat losses.

Loss of Heat. The loss of heat from any hot object is accomplished in three ways: by convection, by conduction and by radiation. In all practical cases a body loses heat by a combination of these processes.

When heat is produced in the cylinder by the combustion of the gases, the piston is at or near the upper dead center; that is, it remains nearly stationary when the heat is greatest and when the heat loss per unit area of inclosing walls is most rapid.

Under the usual conditions of ignition, the gas contained in the cylinder must be set into violent motion by the spread of the flame through it, and this motion will aid the dissipation of the heat in the gas to the containing walls. So convection will be an important factor in the process and perhaps the principal factor. Perhaps a part of the gain in power which has resulted, in some instances, from the use of multiple ignition may be due to violent motion of the gas. Practically all air cooled motors have their valves in the head, so the charge is contained between the cylinder walls and the piston head.

The heat absorbed by the water-jacket is equal to the weight of water passed through the jacket multiplied by the temperature range; or, in other words, it is the difference between the temperature of the water when it enters the water-jacket and that of the water when it leaves the jacket. For instance, if the temperature of the entering water is 50° and that of escaping water is 180°, the temperature range is $180° - 50° = 130°$. Then, if the weight of the water passing through the jacket in 1 hour is 100 pounds, the heat carried away is $100 \times 130 = 13.000$ British thermal units.

Fuel Feed, Vacuum.

The Stewart vacuum gasoline tank, Figs. 148 to 152, consists of two chambers. The upper one is the float or filling chamber, and the lower one is the reservoir or empty chamber. The upper chamber is connected with the intake manifold of the motor, and also with the main gasoline supply tank. The lower or emptying chamber is connected with the carburetor. Between these two chambers is a valve. The suction of the piston on the intake stroke creates a vacuum in the upper chamber. This closes the valve between the two chambers, and in turn draws gasoline from the main supply tank. The gasoline, being sucked or pumped up into this upper chamber, operates a float valve. When this valve has risen to a certain mark it automatically shuts off the suction valve and opens an air valve. This open air valve creates an atmospheric condition in the upper chamber and opens the valve into the lower chamber, and the gasoline immediately commences to flow to the lower or emptying chamber. The lower chamber is always open to outside atmospheric conditions, so that the filling of the upper chamber in no way interferes with an even, uninterrupted flow of gasoline from this lower chamber to the carburetor.

A is the suction valve for opening and closing the connection to the manifold and through which a vacuum is extended from the engine manifold to the gasoline tank.

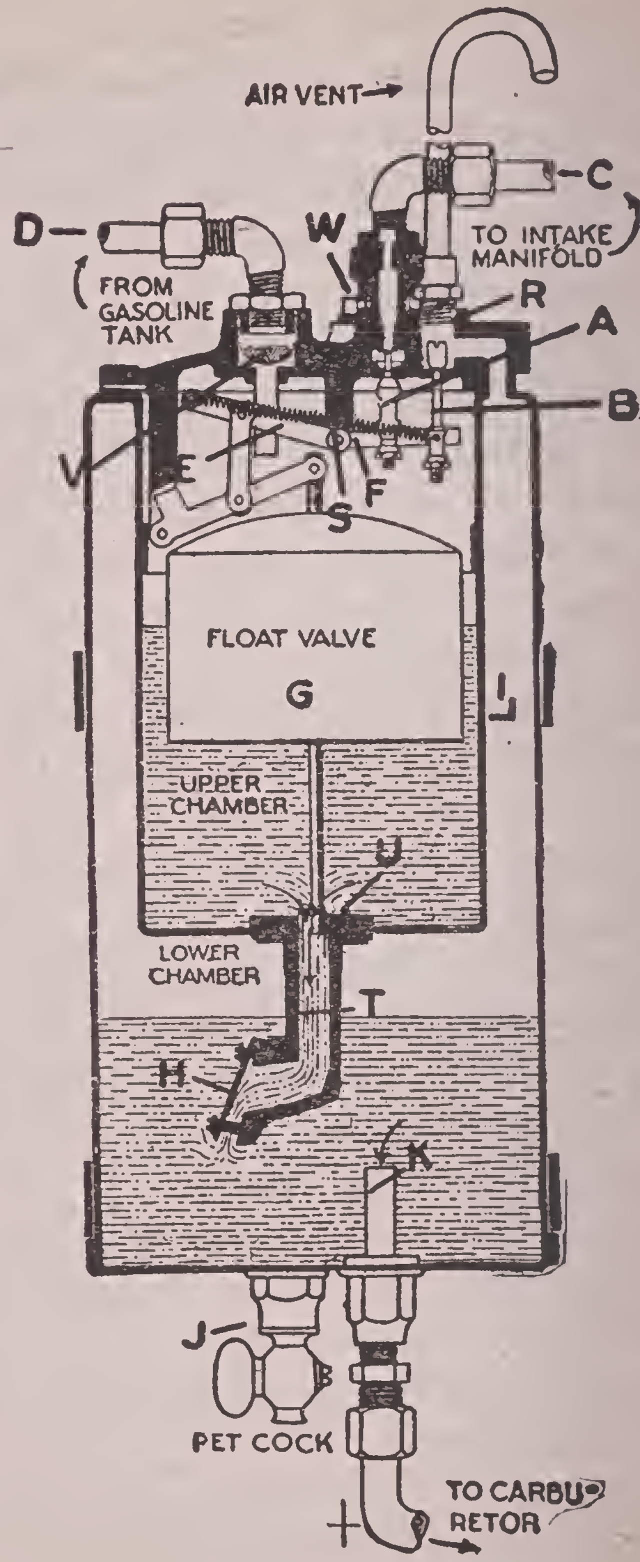


Fig. 148

Stewart Vacuum Fuel Feed Tank

B is the atmospheric valve, and permits or prevents an atmospheric condition in the upper chamber. See Fig. 149. When the suc-

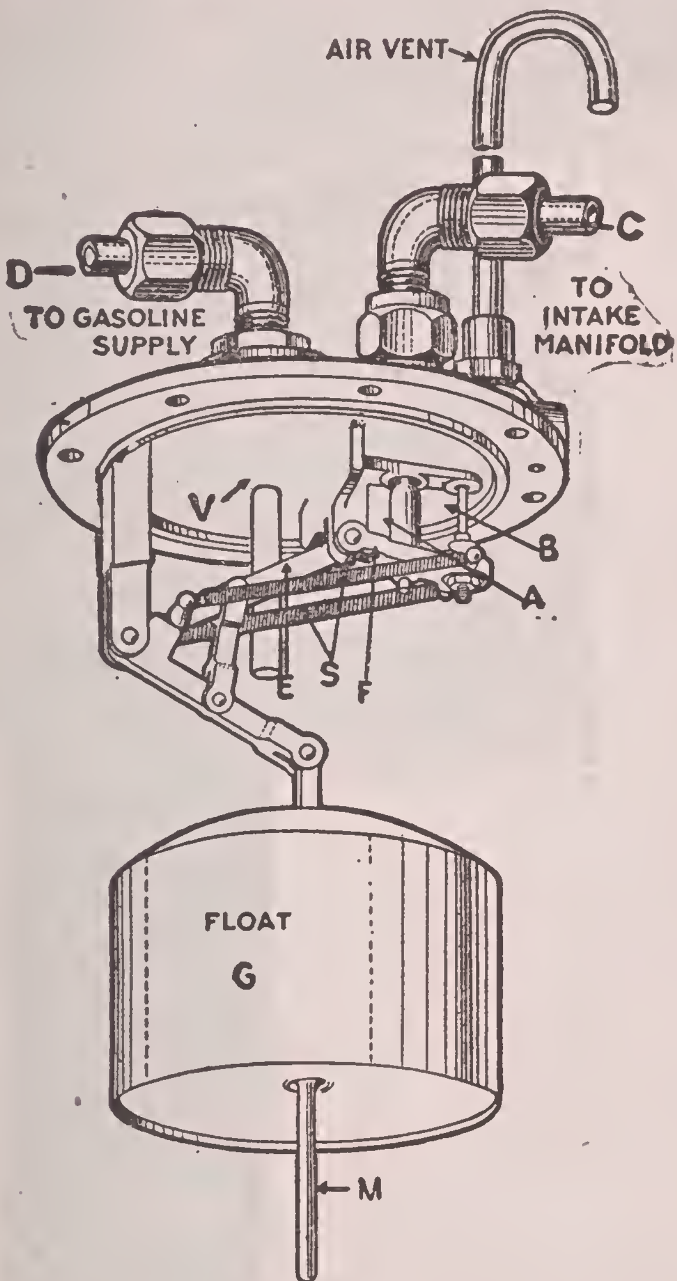


Fig. 149
Float and Levers of Vacuum Tank

tion valve A is open and the suction is drawing gasoline from the main reservoir, this atmospheric valve B is closed. When the suction

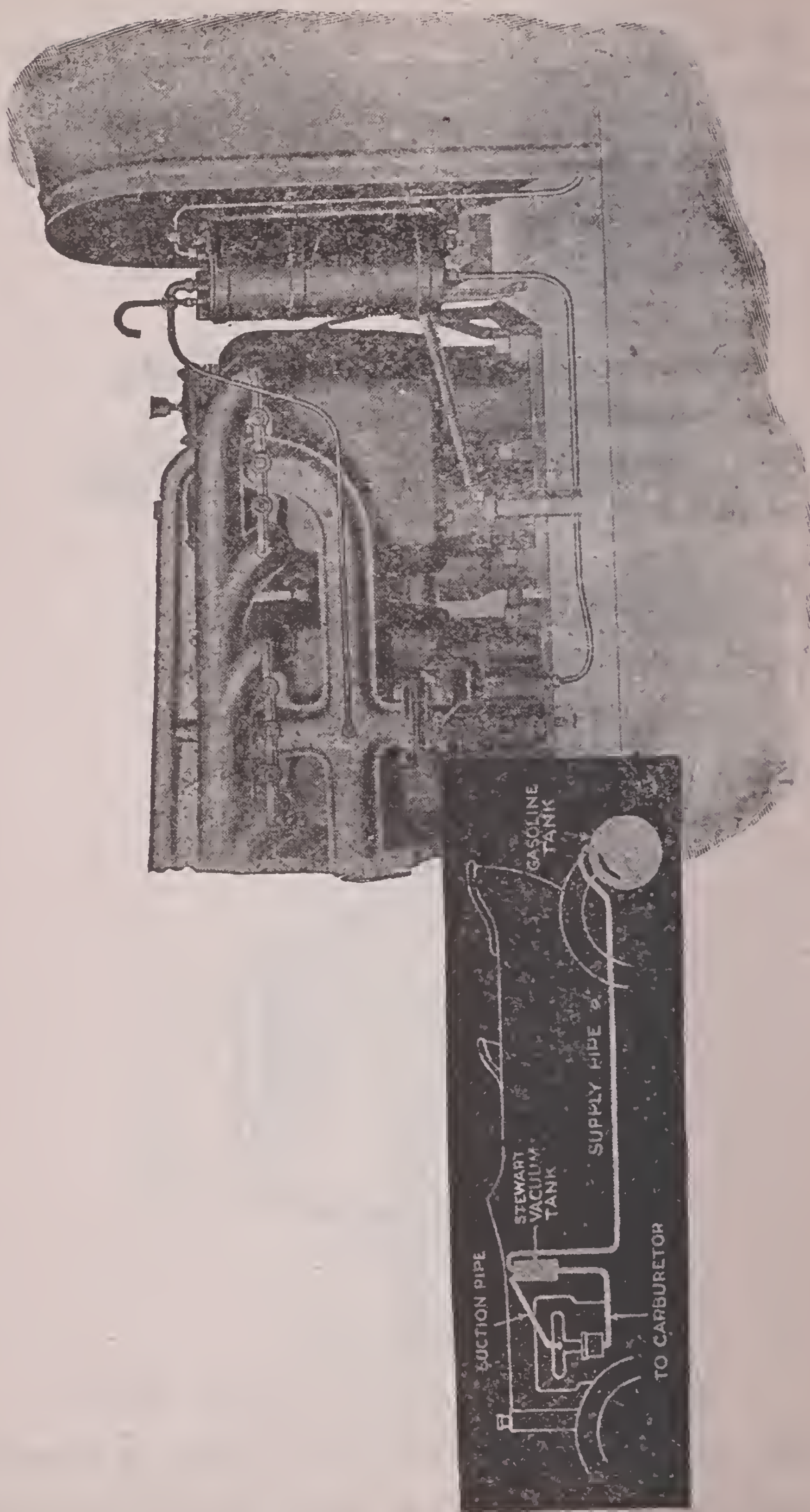


Fig. 150
Arrangement of Parts of Vacuum Fuel Feed

valve A is closed, then the atmospheric valve B must be open, as an atmospheric condition is necessary in the upper tank in order to allow the fuel to flow through the flapper valve H into the lower chamber.

C is a pipe connecting tank to manifold of engine.

D is a pipe connecting vacuum tank to the main gasoline supply tank.

E is a lever to which the two coil springs S are attached. This lever is operated by the movement of the float G.

F is a short lever, which is operated by the lever E and which in turn operates the valves A and B.

G is the float.

H is flapper valve in the outlet T. This flapper valve is held closed by the action of the suction whenever the valve A is open, but it opens when the float valve has closed the vacuum valve A and opened the atmospheric valve B.

J is a pet cock for drawing water or sediment out of the reservoir. This may also be used for drawing gasoline for priming or cleaning purposes.

K is a line to the carburetor extended on inside of the tank to form a pocket for trapping water and sediment which may be drawn out through pet cock J.

L is a channel space between inner and outer shells, and connects with air vent R, thus maintaining an atmospheric condition in the lower chamber at all times, and thereby permitting an uninterrupted flow of gasoline to the carburetor.

M is the guide for float.

R is an air vent over the atmospheric valve. See Fig. 151. The effect of this is the same as if the whole tank were elevated and is for the purpose of preventing an overflow of gasoline should the position of the car ever be such

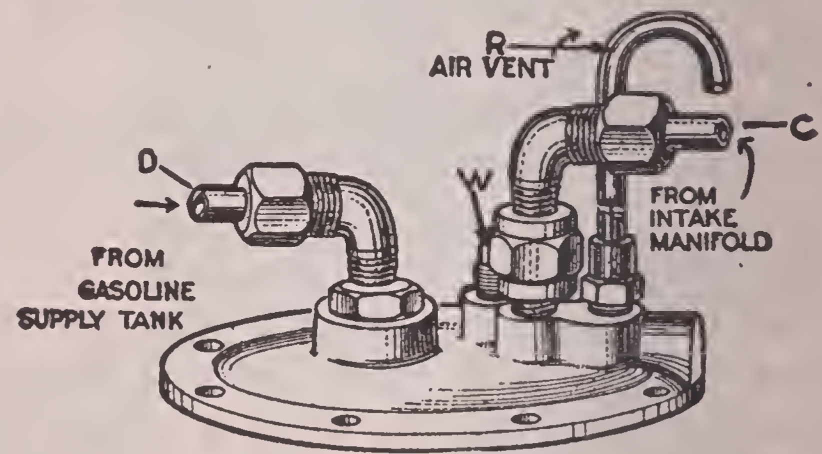


Fig. 151

Upper Connections of Vacuum Tank

as would raise the gasoline supply tank higher than the vacuum tank. Through this tube also the lower, or reservoir chamber, is continually open to atmospheric pressure, so that the flow of gasoline from this lower chamber to the carburetor is always allowed.

T is the outlet located at the bottom of the float reservoir in which is the flapper valve H.

The flapper valve is ground on its seat and should be trouble-proof. A small particle of dirt getting under the flapper valve might prevent it from seating absolutely air-tight and thereby render the tank inoperative: In order to determine whether or not the flapper valve is out of commission, first plug up air vent; then detach tubing from bottom of tank to carburetor. Start motor and apply finger to this opening. If suction is felt continuously, then it is evident that there is a leak in the connection between the tank and the main gasoline supply or else the flapper valve is being held off its seat and is letting air into the tank instead of drawing gasoline.

Any troublesome condition of the flapper valve can be remedied by removing tank cover, then lift out the inner tank. Fig. 152. The flapper valve will be found screwed into the bottom of this inner tank.

Coupling and elbow connections should be kept screwed down tight. Care should be taken that tubing contains no sharp flat bends that might retard the gasoline flow.

Gasoline for priming or cleaning purposes can be obtained by opening pet cock.

To make certain that the tank is not at fault in case of trouble, take out the inner tank entirely. This will leave only the outer shell, which will then be nothing more than an ordinary gravity tank. Fill this tank with gasoline and start to run. If you still have trouble it will be apparent that the fault lies elsewhere and not in the tank.

Carburetor pops and spits are due to improper carburetor adjustments. Running the engine at low speed with an open throttle for any length of time might not produce sufficient suction to fill the tank when empty. But this condition might take place because of dirt or foreign matter getting in and clogging the gasoline feed tube.

If you have any doubt as to the tank being full of gasoline, it is only necessary to close the throttle and the suction of the motor will then fill the tank almost instantly.

To fill the tank, should it ever become entirely empty, close the engine throttle and turn the engine over a few revolutions. This will create sufficient vacuum in the tank to fill it. If the tank has been allowed to stand empty for a considerable time and does not easily fill when the engine is turned over, look for dirt or sediment under the flapper valve H, or the valve may be dry. Removing the plug W in the top and squirting a little gasoline into the tank will wash the dirt from this valve; also wet the valve and cause the tank to work immediately. This flapper valve sometimes gets a black carbon pitting on it, which may tend to hold it from being sucked tight on its seat. In this case the valve should be scraped with a knife.

If the motor speeds up when the vacuum tank is drawing gasoline from the main supply it shows that either the carburetor mixture is too rich, or the connections are so loose that it is drawing air into the manifold. There should

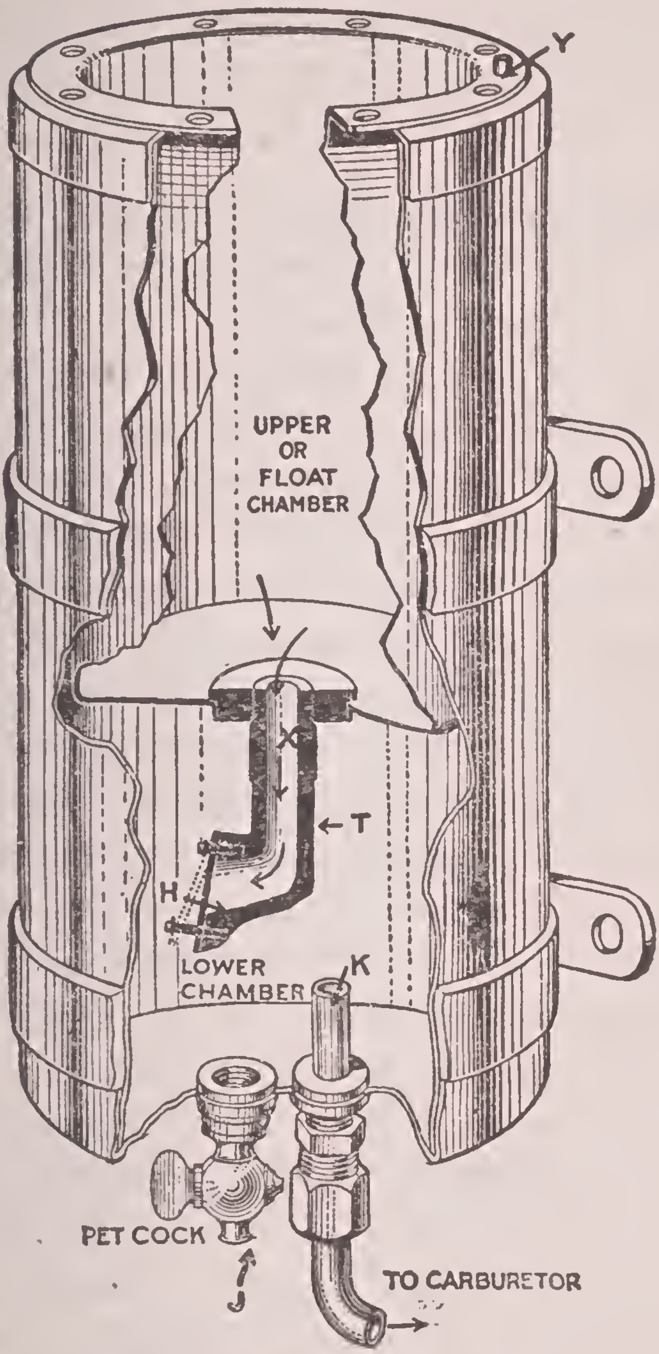


Fig. 152
Shell of Vacuum Tank

be no perceptible change of engine speed when the tank is operating.

Gases, Expansion of. All gases expand equally, 1/273 part of their volume for each degree of temperature, Centigrade, of 1/491 part of their volume for each degree of temperature, Fahrenheit.

Gasoline, How Obtained. Benzine, Gasoline, Kerosene and the kindred hydro-carbons are products of crude petroleum.

They are separated from the crude oil by a process of distillation. The process is very similar to that of generating steam from water.

Crude petroleum subjected to heat will give off in the form of vapor such products as Benzine, Gasoline and Kerosene, etc. The degrees of heat at which these products are separated are comparatively low. Various degrees of heat will separate the distinct products. As a means of illustration, it may be said that the crude oil when raised to certain temperatures gives off vapors which when cooled liquefy into oils.

VISCOSITY OF GASOLINE. It is a mistake to assume that because gasoline does not thicken up, it is not retarded in its flow through the nozzle of the carbureter. Taking gasoline having a specific gravity of 0.71 the quantity that will pass through the nozzle of a carbureter under a given pressure will increase as the temperature is increased, as shown in the following table:

Temp. degrees F.	Relative Flow.
50°	1
59°	1.073
68°	1.145
77°	1.212
86°	1.27
95°	1.335

Since carbureter nozzles are not readily adjustable, nor with any degree of certainty, it follows from the above that the influence of temperature upon the weight of fuel ejected will most certainly affect the efficiency of the carbureter. This source of trouble goes to indicate that some means of maintaining a constant temperature is of the greatest advantage, and in a measure it argues for the adaptation of water (hot) jacketing, not around the depression chamber, as is usually the practice, but around the gasoline (float) bowl, in order to maintain a constant temperature of the liquid gasoline as it flows through the nozzle.

Gasoline Explosions. There are two entirely different kinds of explosion, which would undoubtedly both be referred to as gasoline explosions. The real gasoline explosion is the kind taking place in the cylinder of a gasoline motor, in which heat and pressure are suddenly produced by the combustion of gasoline vapor in air. The other kind of explosion referred to may be explained as follows:

If a tank of gasoline be placed on a woodpile and the latter set on fire, the heat would raise a pressure in the tank, which would rapidly increase and the tank would finally explode from the pressure. The gasoline would then be thrown in all directions, and, owing to its superheated condition, the greater part of it at least would instantly vaporize, mix with the air of the atmosphere and be ignited by the flame which caused the explosion.

Gasoline Fires, Extinguishing. A number of fires have been caused by leaky gasoline pipes on automobiles, and many persons would like to know of chemicals which can be used to put out such fires. Water is exceedingly dangerous to use, and it is not always possible to get at the fire to smother it with wet rags or waste.

In case of fire due to gasoline, use fine earth, flour or sand on top of the burning liquid.

A dry powder can be used for this purpose which will extinguish the fire in a few seconds. It is made as follows: Common salt, 15 parts—sal-ammoniac, 15 parts—bicarbonate of soda, 20 parts. The ingredients should be thoroughly mixed together and passed through a fine mesh sieve to secure a homogeneous mixture.

If by any chance a tank of gasoline takes fire at a small outlet or leak, run to the tank and not away from it, and either blow or pat the flame out. Never put water on burning gasoline or oil, the gasoline or oil will float on top of the water and the flames spread much more rapidly.

Several gallons of ammonia, thrown in the room with such force as to break the bottles which contain it, will soon smother the strongest fire if the room be kept closed.

Gears, Horsepower Transmitted by. The following formulas will give the horsepower that may be transmitted by gears with cut teeth of involute form and of various metals.

H.P = Horsepower.
P = Pitch diameter in inches.
C = Circular pitch in inches.*
F = Width of face in inches.
R = Revolutions per minute.

$$H.P = \frac{P \times C \times F \times R}{90} \quad \text{(Annealed tool steel.)} \quad (1)$$

$$H.P = \frac{P \times C \times F \times R}{140} \quad \text{(Mach. steel or Phosphor Bronze.)} \quad (2)$$

$$H.P = \frac{P \times C \times F \times R}{410} \quad \text{(Cast Brass.)} \quad (3)$$

$$H.P = \frac{P \times C \times F \times R}{550} \quad \text{(Cast Iron.)} \quad (4)$$

Example: Required, the horsepower which a tool steel pinion, 2 inches pitch diameter, 1 inch face and No. 10 diametral pitch, will transmit at 900 revolutions per minute.

Answer: From the table the circular pitch corresponding to No. 10 diametral pitch is

---

*The circular pitch corresponding to any diametral pitch number, may be found by dividing the constant 3.1416 by the diametral pitch.

Example: What is the circular pitch in inches corresponding to No. 6 diametral pitch.

Answer: The result of dividing 3.1416 by 6 gives 0.524 inches as the required circular pitch.

0.314. Then by Formula No. 1, $2 \times 0.314 \times 1 \times 900$ equals 565.2. This, divided by 90, gives 5.29 horsepower.

Gear, Internal-Epicyclic. It is often desired to ascertain the speed of rotation of the different members of this form of gearing. To calculate their speeds, the following formulas are given, which, by reference to the letters designating the different parts in Figure 153, may be readily solved.

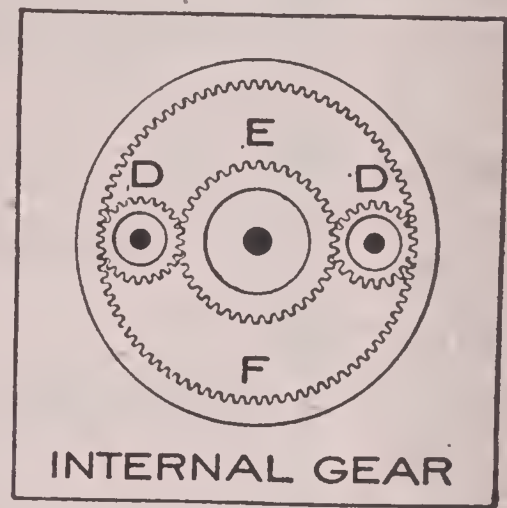


Fig. 153

Let R be the revolutions per minute of the disk or spider carrying the pinions D.

Let N be revolutions per minute of the gear E.

Let G be the revolutions per minute of the internal gear F.

When the internal gear F is locked and gear E rotating, the speed in revolutions per minute of the disk or spider carrying the pinions D is

$$R = N \frac{E}{E + F}$$

If the internal gear be locked and the spider carrying the pinions D be rotated, then the speed in revolutions per minute for the gear E will be

$$N = R \frac{E + F}{E}$$

If the spider carrying the pinions D be held rigid and the gear E be rotated, the speed in revolutions per minute for the internal gear F is

$$G = \frac{N \times E}{F}$$

If the pitch diameter of the gears is not readily obtainable, the number of teeth in each gear may be used instead, as the result will be exactly the same.

It will be recognized that this is the form of gearing employed in the older forms of planetary transmission devices. Newer types use no internal toothed gears.

Horsepower. The actual horsepower of an engine can only be determined by making a test with suitable brakes or dynamometers. This method would give the actual brake horsepower. In order to allow ready calculation, the Society of Automobile Engineers' formula is used and is generally recognized. The bore or diameter of the cylinder is first squared; that is, the size in inches is multiplied by itself. This

TABLE 12

HORSEPOWER OF GASOLINE ENGINES

(S. A. E. Four Cycle Formula)

Bore	4 cyl.	6 cyl.	8 cyl.	12 cyl.
2½	10.0	15.0	20.0	30.0
2¾	12.1	18.2	24.2	36.3
2⅞	13.2	19.8	26.4	39.6
3	14.4	21.6	28.8	43.2
3⅛	15.6	23.4	31.2	46.9
3¼	16.9	25.4	33.8	50.7
3⅜	18.2	27.3	36.5	54.7
3½	19.6	29.4	39.2	58.8
3⅝	21.0	31.5	42.0	63.1
3¾	22.5	33.8	45.0	67.5
3⅞	24.1	36.2	48.3	72.4
4	25.6	38.4	51.2	76.8
4⅛	27.2	40.8	54.5	91.7
4¼	28.9	43.4	57.8	86.7
4⅜	30.6	45.9	61.2	91.9
4½	32.4	48.6	64.8	97.2
4⅝	34.2	51.3	68.4	102.7
4¾	36.1	54.2	72.2	108.3
4⅞	38.0	57.0	76.0	114.1
5	40.0	60.0	80.0	120.0
5¼	44.1	66.2	88.2	132.3
5½	48.5	72.7	97.0	145.4

NOTE: Above powers are calculated for piston speed of 1000 feet per minute.

number is then multiplied by the number of cylinders and the result divided by 2½. Thus, for an engine with 5-inch bore: 5x5=25. If of 4 cylinders, 25x4=100, and 100 divided by 2½ gives the result as 40 horsepower. In order to secure approximately correct results, the engine is supposed to be operating at 1,000 feet per minute piston speed.

Many formulae, other than that known as the S. A. E., are used in calculating the power of internal combustion engines, and it is upon some of these that the S. A. E. rating was originally based. The methods most used in making such calculations, either for four cycle or two cycle engines are explained in the following pages.

Horsepower of Explosive Motors. The first requisite is to find the number of power strokes made per minute by the motor. In a single cylinder motor of the four-cycle type there is one power stroke for every two revolutions, and if the motor has four cylinders there is one power stroke for every revolution of the crank shaft. The number of power strokes then may be found by the following formula (referring to a four-cycle motor):

$$N = \frac{C}{4} \times S$$

in which N = Number of power strokes per minute.

C = Number of cylinders.

S = Angular velocity of crank shaft in revolutions per minute.

Having ascertained the number of power strokes per minute, the horsepower is found by the formula,

$$H.P = \frac{PLAN}{33{,}000}$$

P = Mean effective pressure (M. E. P.).
L = Length of stroke in feet.
A = Area of piston in sq. in.
N = Number of power strokes per minute.

This formula does not discriminate between mechanical friction and losses in "fluid" friction. A formula that is more arbitrary and that fits the majority of cases, requiring only the use of a few facts, such as diameter of cylinder, length of stroke, and revolutions per minute, is presented as follows:

$$H.P = \frac{V \times N}{10,000}$$

in which

V = volume of cylinder in cu. inches.
N = number of power strokes per min.

The constant used varies from 9,000 to 14,000 depending upon certain types of engines; 10,000 being an average figure for four cycle engines. The brake horsepower will be from 65 to 85 per cent of the result obtained; 80 per cent may be taken as an average. As an example we may take a four-cycle, four-cylinder motor 4½-in. bore and 4½-in. stroke making 1,200 power strokes per minute. Volume (V) of cylinder equals area of piston 15.9 sq. in. × length of stroke 4½=71.55 cu. in., and multiplying this by 1,200 (N) and dividing the product by 10,000 gives 8.05 H.P. Taking 80 per cent of this as the brake horsepower the result is 6.44 H.P.

From a theoretical standpoint a two-cycle explosive motor should not only have as great a speed, but also be capable of developing almost twice the power that a four-cycle motor does. It is a fact nevertheless that its actual performance is far different.

The horsepower of a two-cycle motor may be calculated from the following formula,

$$H.P = \frac{D^2 \times S \times N}{21{,}000}$$

in which

D=diameter of cylinder in inches.
S=stroke of piston in inches.
N=number of revs. per minute.

Example: Required, the horsepower of a two-cycle motor of 4½ inches bore and stroke, with a speed of 900 revolutions per minute.

Answer: The square of the bore multiplied by the stroke is equal to 91.125, which multiplied by 900, and divided by 21,000, gives 3.91 as the required horsepower. The results given by the above examples agree very closely with those obtained from actual practice.

Horsepower, Electrical. One electrical horsepower is equal to the current in amperes multiplied by the electro-motive force or voltage of the circuit and divided by 746.

Let C be the current in amperes and E the voltage of the circuit. If E. H. P. be the required electrical horsepower, then

$$E.H.P = \frac{E \times C}{746}$$

In practice with motors of small power, 1,000 watts are necessary to deliver one mechanical or brake horsepower at the driving shaft of the motor.

If the actual or brake horsepower of an electric motor be known, the efficiency of the motor may be readily found by the following formula:

If E be the voltage of the circuit and C the current in amperes consumed by the motor, let B. H. P be the brake horsepower of the motor and e the efficiency of the motor, then

$$e = \frac{B.H.P \times 746}{E \times C}$$

Ignition Systems.

Ignition. In order that an explosive motor may operate economically, and with the highest percentage of efficiency, it is absolutely necessary that two objects shall be attained, viz.: A

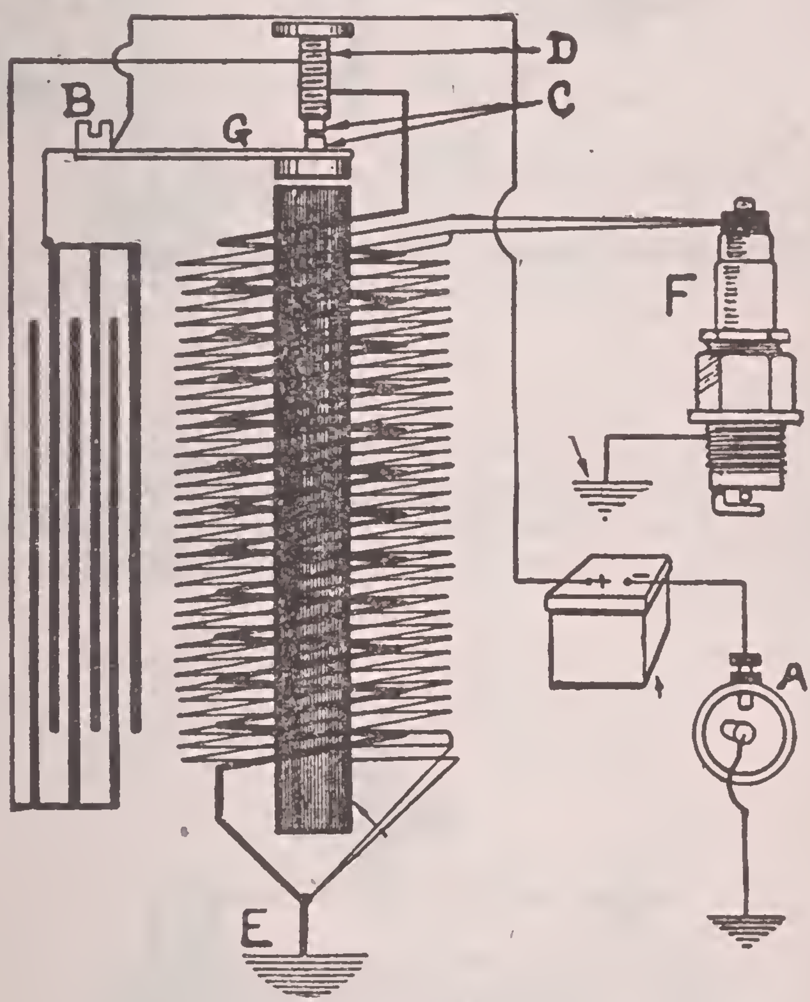


Fig. 154
Coil and Timer Ignition With Storage Battery

correct mixture of the gasoline and air, and that this mixture be correctly ignited at the proper time.

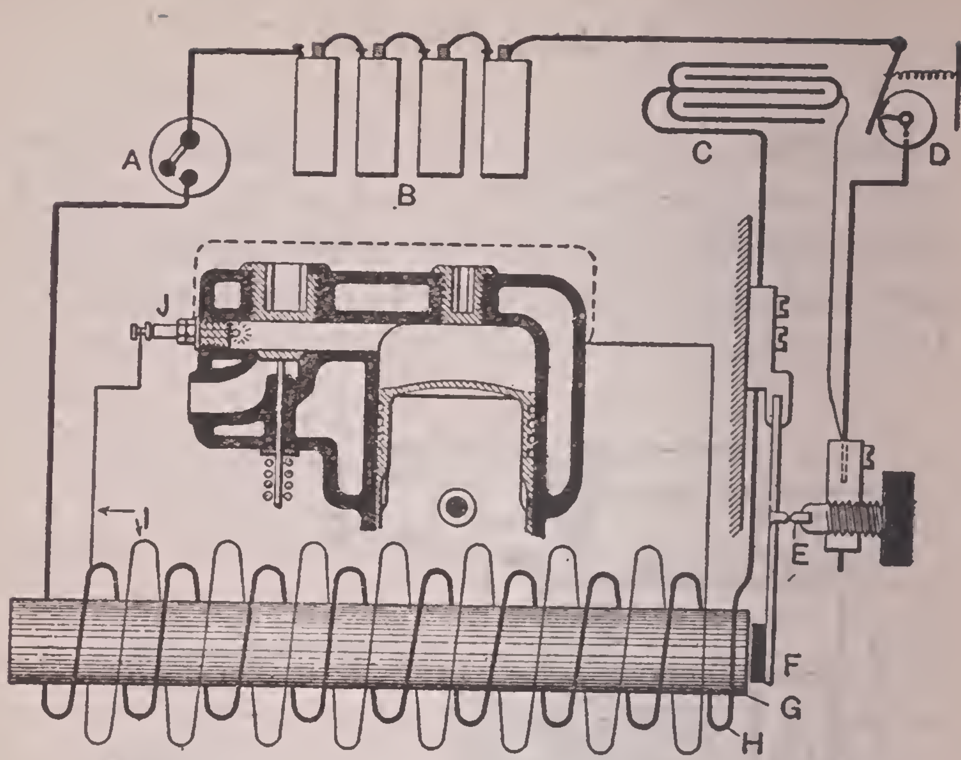


Fig. 155

Coil and Timer With Dry Cells. A, Switch. B, Dry Cells. C, Condenser. D, Timer. E, Contacts. F, Armature. G, Core of Coil. H, Primary Winding. I, High Tension Winding. J, Spark Plug.

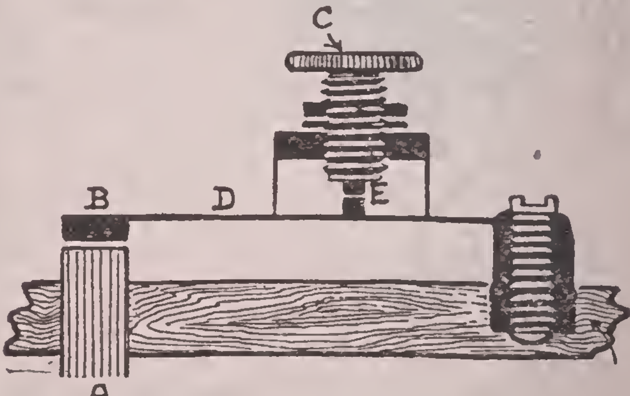


Fig. 156

Coil Vibrator Principle. A, Core of Coil. B, Armature of Coil Magnet. C, Adjusting Screw. D, Trembler Blade. E, Contacts.

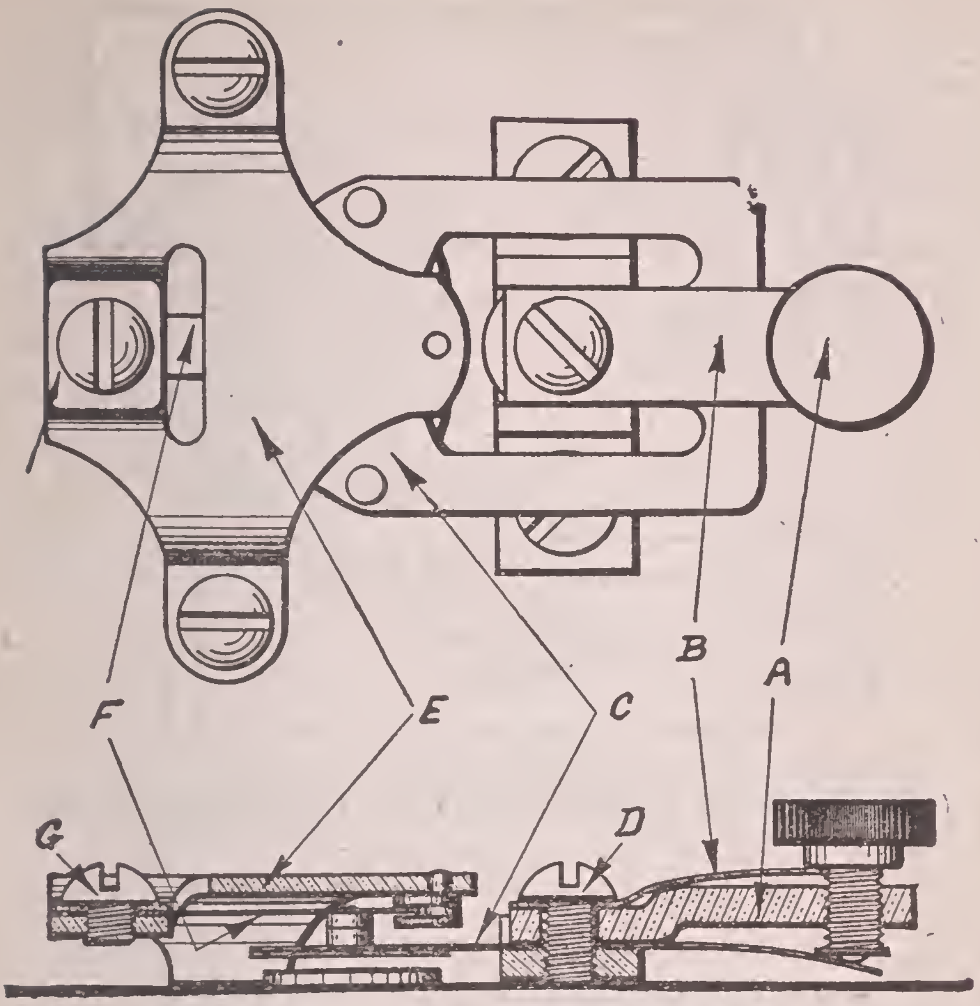


Fig. 157

Coil Vibrator Details. A, Adjustment. B, Tension Spring. C, Trembler Blade. D, Holding Screw. E, Contact Bridge. F, Contact Blade. G, Locking Screw.

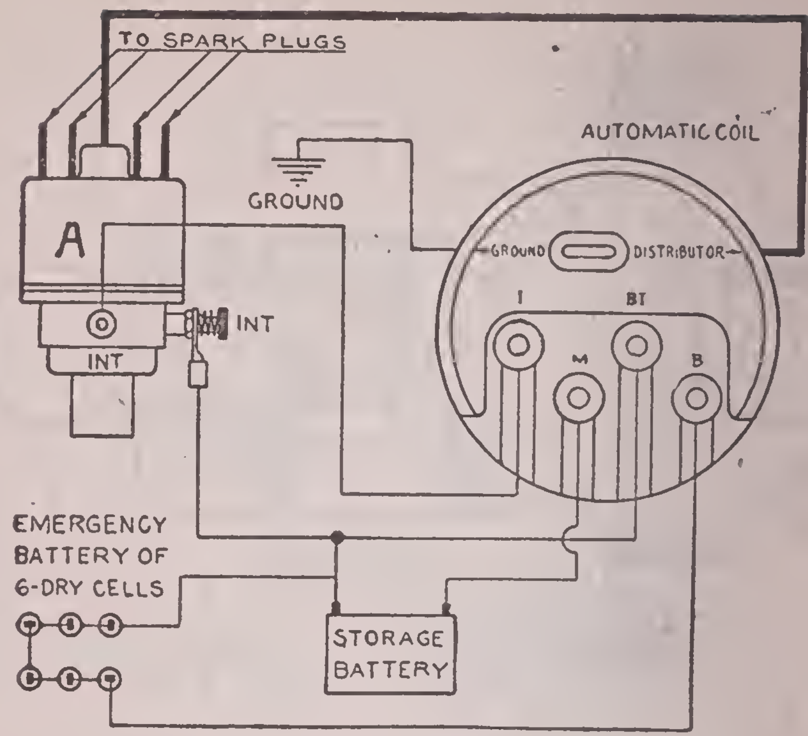


Fig. 158
Connecticut Storage Battery Ignition Wiring

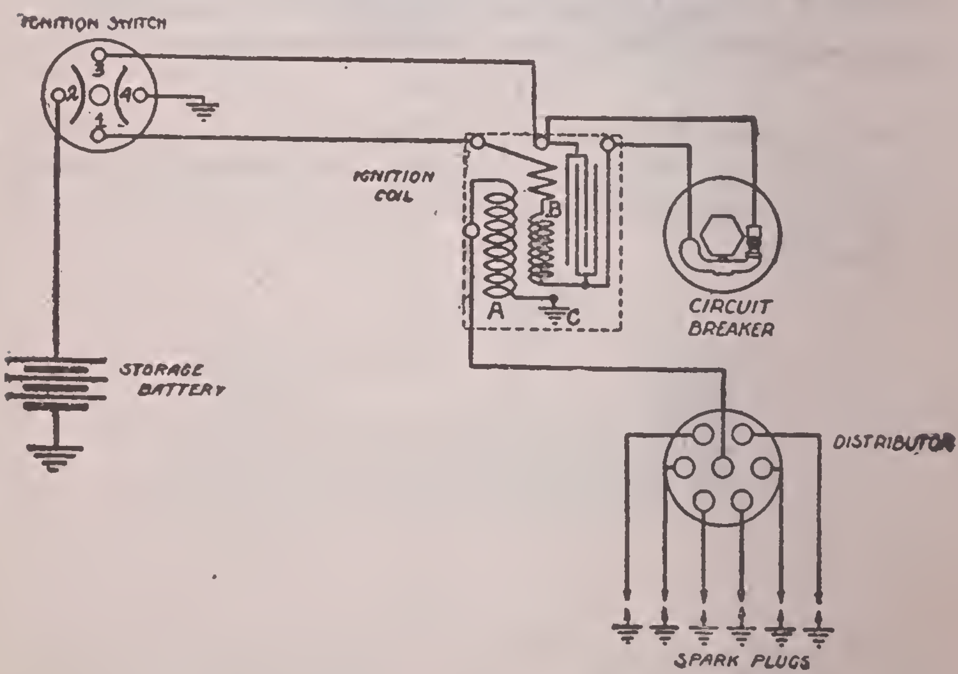


Fig. 159
Circuits Through Remy Battery Ignition System

INDUCTION COIL. Induction is the process by which a body having electrical or magnetic properties calls forth similar properties in a neighboring body without direct contact. This property is known as self-induction, and is caused by the reaction of different parts of the same circuit upon one another, due to variations in distance or current strength. The current produced by an induction coil has a very high electro-motive force, and hence great power of overcoming resistance.

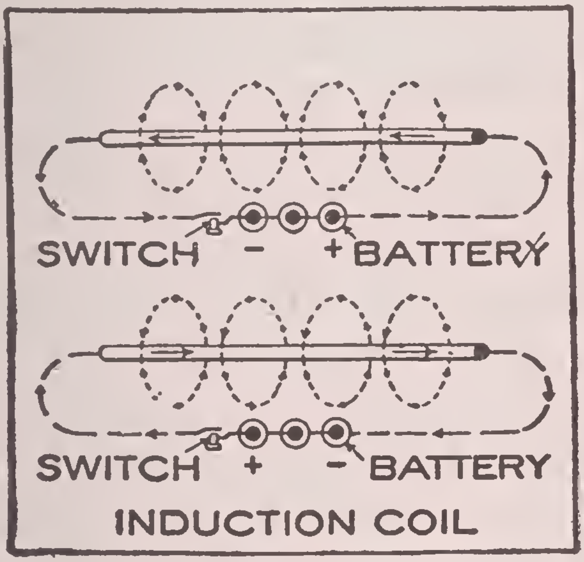


Fig. 160.

If a current of electricity be caused to flow through a straight conductor forming a part of a closed electric circuit, lines of force, commonly called magnetic whirls or waves, are induced in the air and rotate around the conductor.

If the current of electricity be flowing in the circuit and through the straight conductor from right to left, as shown in the upper view in Fig. 160, the lines of force or magnetic whirls will rotate around the conductor from left to right, or in the direction of the hands of a clock. On the other hand, if the conditions be reversed and the current flows from left to right the lines of force or magnetic whirls will rotate from right to left, as shown in the lower view in Fig. 160. The direction of rotation of these lines of force or magnetic whirls may be positively determined by the use of a galvanometer, an electric testing instrument having a needle similar in appearance to that of an ordinary compass. Upon placing this instrument in the path of the lines of force and making and breaking the battery circuit by means of the switch, the needle of the galvanometer will be deflected from its zero point in the direction of the rotation of the lines of force. If the direction of the flow of the electric current through the circuit be changed by reversing the poles of the battery, the needle of the galvanometer will be deflected from its zero point in the opposite direction. Whether these lines of force or magnetic whirls rotate continuously around the wire has not been demonstrated. They rotate with sufficient force to be tested by the galvanometer only until the electric current in the closed circuit has reached its maximum value after closing the circuit; that is to say, only during the infinitesimal space of time required by the current to reach its full value or power.

If, instead of a straight conductor, a loop of insulated wire, in the form of a circle, be untilized for the passage of the current, as at A and B in Fig. 161, the lines of force will still rotate around the wire as shown, their direction being dependent on the direction of the electric current. If the electrical circuit be provided with

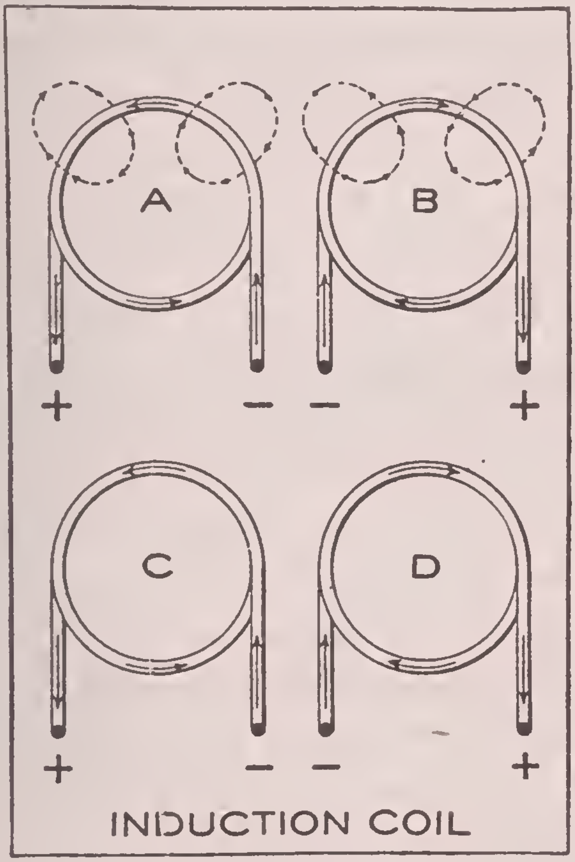


Fig. 161

a current reverser, or device for changing the battery connections in the circuit from positive to negative and vice versa, the lines of force can be made to rotate rapidly first in one direction and then in the other, as indicated in Fig. 160.

Suppose this loop of insulated wire be composed of a great number of turns, it then becomes a coil or closed helix, and as all the lines of force cannot pass between the turns of the electrical conductor forming this helix they must pass completely through the helix instead of rotating around a single loop, as at A and B, Fig. 161. If the current flows through the conductor in the direction indicated by the arrows, at C in Fig. 161, and over and around the coil in the direction shown, the lines of force will flow through the coil towards the observer, and complete their path or circuit through the air, returning into the coil at the opposite end. If the current be reversed and flow around the coil in the direction of the hands of a clock, the lines of force will flow through the coil in the opposite direction, that is, away from the observer, as at D, Fig. 161.

This form of coil or closed helix may be designated as the primitive form of an electromagnet. When forming part of a closed electric circuit it possesses the property of magnetizing a bar of wrought iron placed within it. If a short round bar of wrought iron be placed a short distance within the coil, and the battery circuit be closed, the iron bar will, if the current is sufficiently strong, be sucked or drawn into the center of the coil, and a considerable effort will be required to withdraw it.

The object of the bundle of soft iron wires, which form the core of any form of spark coil, is to increase the magnetic effect of the lines of force or magnetic flux, or rather to reduce the resistance to their passage through the coil.

As has been previously stated, when a current of electricity flows through a conductor of wire forming a coil or closed helix, lines of force are induced and flow through, and also around the exterior of the coil. In a like manner, when the electric circuit is broken, the lines of force suddenly reverse their direction, and travel through the coil with a tremendous velocity until they

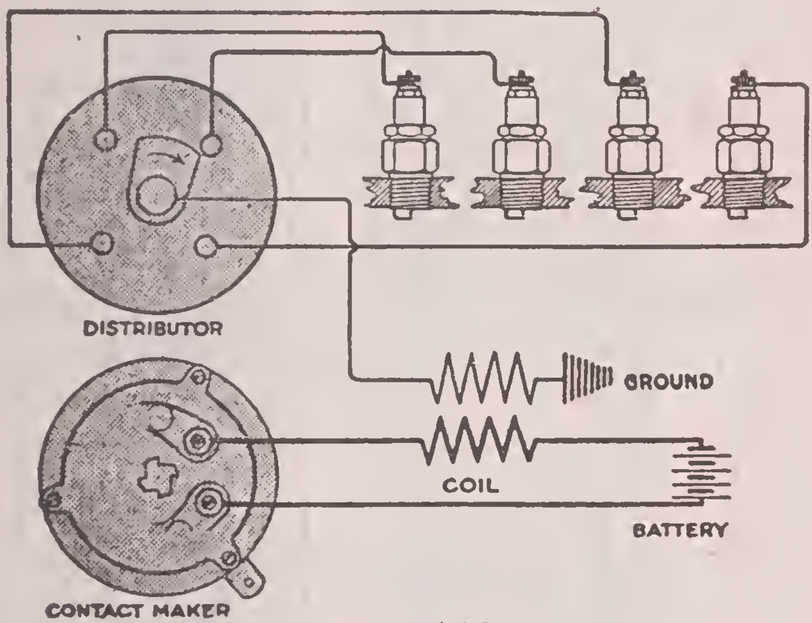
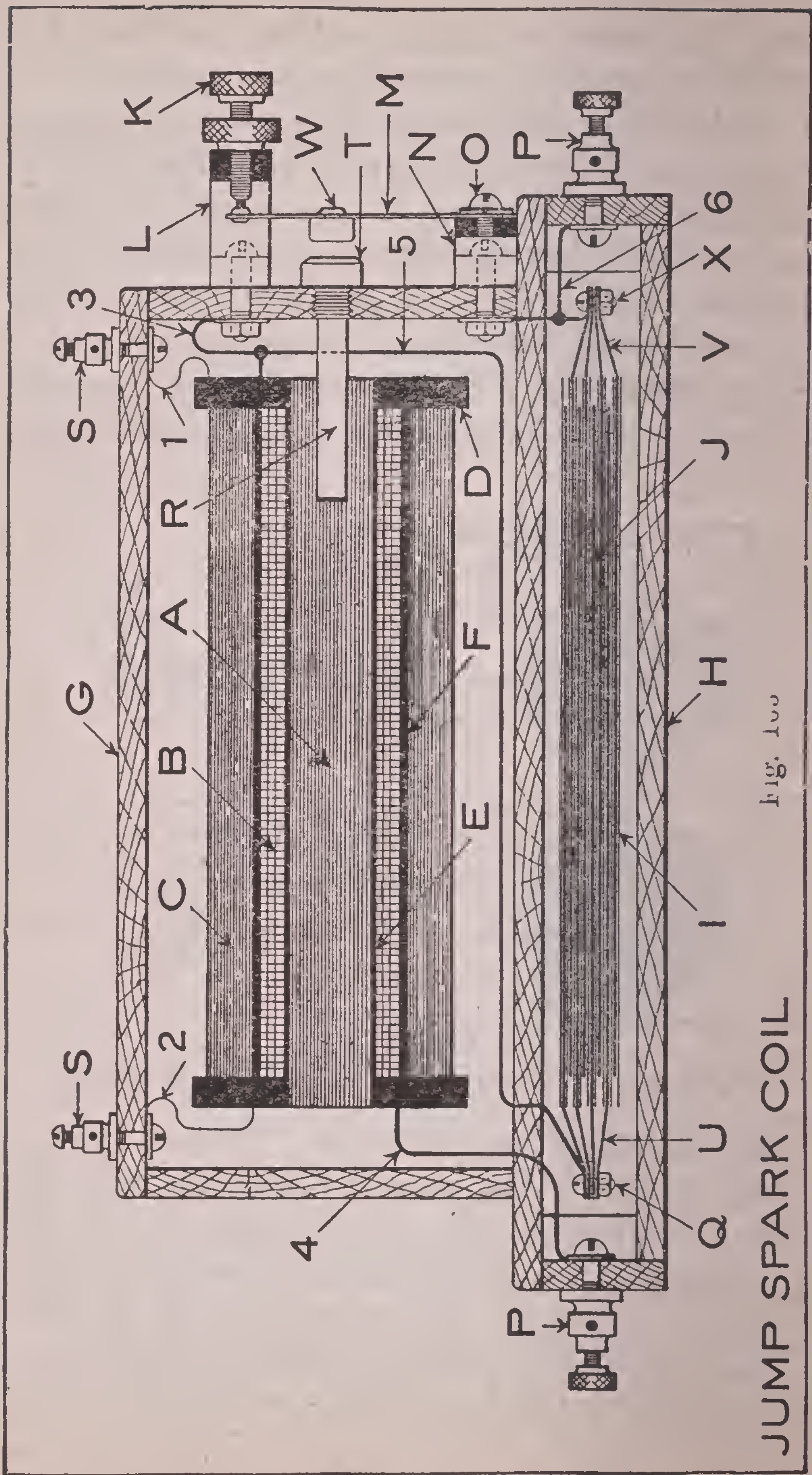


Fig. 162
Principle of Atwater Kent Battery Ignition

reach a state of neutralization. During this reverse travel of the lines of force through the coil, a current of electricity is induced in the winding of the coil, but in the opposite direction to that in which the battery current was flowing. The effect of this induced current, which is of far greater intensity or pressure than the bat-



JUMP SPARK COIL

tery current which induced it, is to form an arc or spark at the breaking point in the circuit.

SECONDARY SPARK COIL. Fig. 163 shows the secondary or jump-spark form of coil. It is composed of an iron core and a primary winding similar to that described in conjunction with Fig. 162, with the addition of an outer winding of many turns of fine wire. This wire, of very small size, is known as the secondary winding, varying in diameter from No. 36 to No. 40 B. & S. Gauge, and in length from 5,000 to 10,000 feet. In the drawing the induction coil is shown equipped with an electro-magnet make and break, or vibrator device, which is the form mostly used for ignition purposes. The other form, known as the plain jump-spark coil, has a mechanically operated make and break device attached to the motor to operate the coil.

The arc or spark produced at the breaking point of the electrical circuit in which the primary winding of the coil is connected is not utilized for ignition purposes in this type of coil. When the circuit is broken the sudden reaction or backward flow of the lines of force or magnetic flux in the iron core produce an induced current in the secondary winding, but in the opposite direction to that of the battery current. This induced current is of so much greater intensity and velocity than that induced in the primary winding by this same reaction, that the arc or spark induced in the secondary winding of the coil will jump across a space from one end of the wire to the other, varying from ⅛ inch to as much as 8 or 10 inches in length, dependent upon the length of wire in the secondary circuit, the electro-motive force of the battery and the frequency of the interruptions or number of times per minute the electric circuit is made and broken.

Referring to Fig. 163 A is the core, B the primary winding and C the secondary. The two coils are held in place upon the core by the washers D. The primary wire B is wound over a paper tube E, and the secondary wire C is insulated from the primary wire by a mica insulating tube F. The coil proper is enclosed in a wood case G.

The terminals or binding posts on top of the case G are connected with the ends of the secondary wire 1 and 2. The secondary terminals are plainly indicated by the letter S. In the base H of the coil case is the condenser J, an essential feature of this form of coil, which utilizes the induced primary current to produce a greater reactive energy in the secondary winding.

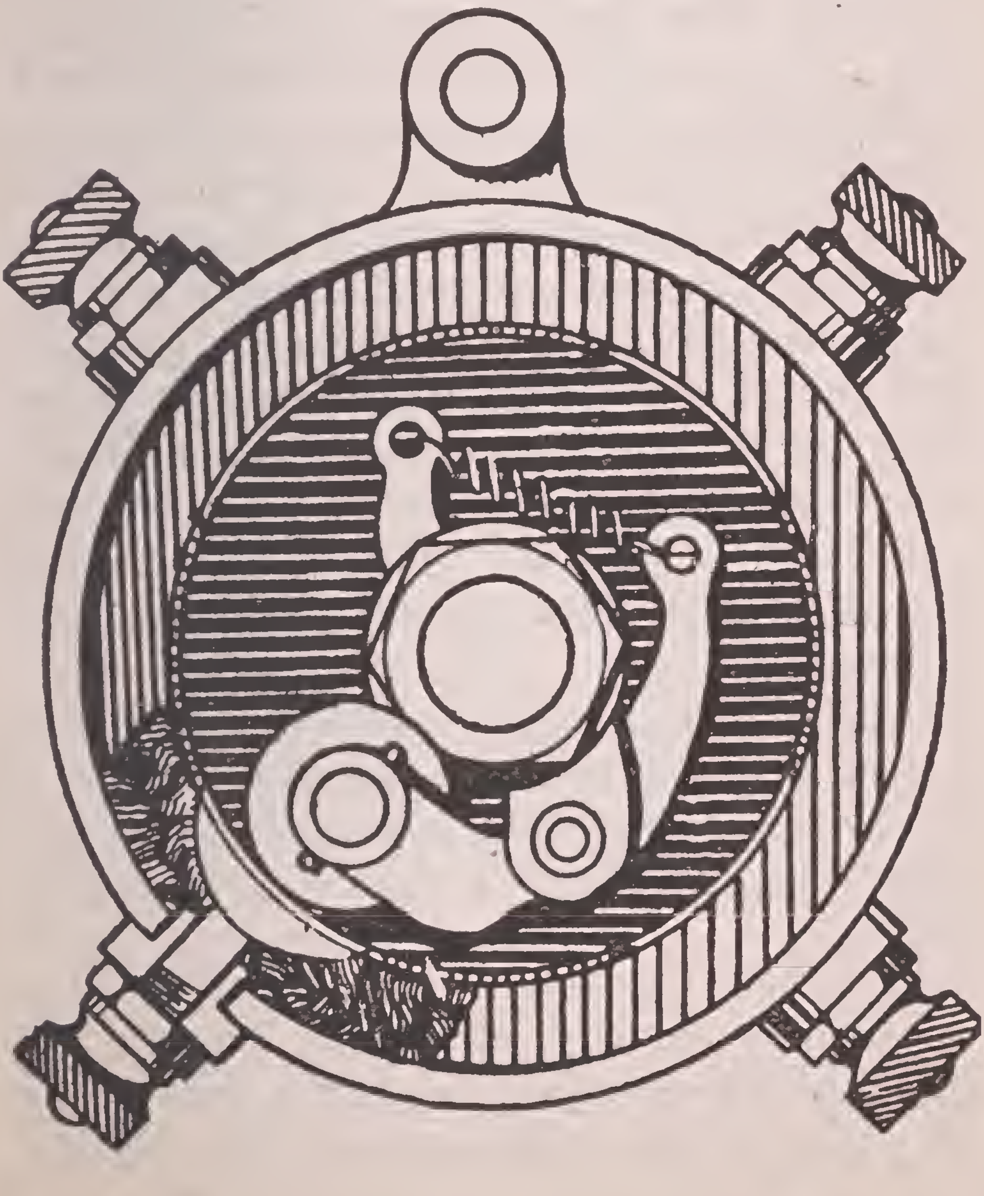
At the right-hand end of the coil and outside the casing G is located the electro-magnetic vibrator or trembling device, which automatically makes and breaks the primary circuit. The end 3 of the primary wire is connected with the contact screw K through the bracket L. The spring M, carried by the bracket N, with screw O, is connected with the terminal or binding post P, immediately beneath it, by the wire 6 through the bracket N. The end 4 of the primary wire is connected with another terminal or binding post P, at the other end of the base of the coil. The condenser J is connected across the contact points of the screw K and the spring M, by the wires 5 and 6 and screws Q and X. The condenser is composed of a number of sheets of tinfoil V, laid between sheets of specially insulated paper I, with the opposite end of every alternate sheet of tinfoil projecting from the paper insulation, as shown. These projecting ends are connected together, and by the wires 5 and 6 to the contact screw K and spring M, respectively, as previously described.

When the coil is connected in, or forms part of a closed electric circuit by means of the terminal or binding posts P, on the base of the coil, the current flows through the primary winding B. This instantly produces a high degree of magnetism in the core A, and the pole-piece T of the core extension R becomes strongly magnetic and attracts the iron button W of the spring M. This draws the spring M away from the end of the screw K, and in consequence breaks the electric circuit. This results in the demagnetizing of the pole-piece T and the consequent return of the spring M to its normal position in contact with the end of the screw K. So long as the electric circuit remains closed this operation is repeated at a very high rate of speed. The effect of this continuous operation of the coil is to produce an intermittent current in the secondary winding of high intensity and velocity. If wires are placed in the holes in the small terminals or binding posts on the top of the coil and brought within a short distance of each other, a stream of sparks will pass from one wire to the other in a peculiar zigzag manner and emit a loud, crackling noise, accompanied by a peculiar odor, caused by the formation of ozone through the electro-chemical action of the spark.

Under ordinary circumstances the arc or spark which occurs on the breaking of the contact between the platinum points of the screw K and spring M would not be utilized, but by means of the condenser in the base, which is connected to these parts, as before described, the static charge of electricity generated by this action is stored in the condenser. When the contact is again made this stored electric energy is given up or discharged by the condenser and flows through the primary winding of the coil in connection and in the same direction as the battery current and increases the magnetic effect of the core A enormously.

The construction and operation of the condenser is fully described under the heading *Condenser*. It should be understood that this is one of the most important elements of the ignition system, whether battery or magneto type, and its care should never be neglected if efficient ignition is desired.

Commutators, Ignition. The commutator of the ignition system of a multi-cylinder gasoline motor has a three-fold use: To switch the battery current in and out of the electrical circuit at the proper time—To transfer the battery current successively from one coil to another—To vary the point or time of ignition of the explosive charge in the motor cylinder. The commutator of the Ford car is shown below.



Distributors. Instead of employing a separate spark coil for each cylinder of a multi-cylinder engine, the primary circuits of which are made and interrupted in rotation, a device known as the distributer may be used, which permits of any number of cylinders being sparked from a single coil. In magnetos designed for jump spark ignition of multi-cylinder engines the distributer forms part of the magneto and is rotated by it. The distributer is nothing more than a timer of secondary current, and generally consists of a cylindrical shell of insulating material, upon the inside of the cylindrical surface of which equidistant metallic segments in number equal to the motor cylinders are inserted. A conducting arm rotating upon a shaft concentric with the insulated shell carries a brush, which successively makes contact with the segments. The arm is in permanent electrical connection with the free secondary terminal of the coil, and each one of the segments is wired to the spark plug of a cylinder.

In the case of four-cylinder motors the moving arm is geared at one-half the speed of the motor, thus making contact for each cylinder once in each two revolutions or complete cycle.

In battery ignition systems the distributor is mounted directly above the breaker and the distributor rotating member is driven from the same shaft which operates the breaker.

Ignition—Timing. In timing the ignition of a motor one should base his operations on one particular cylinder, and this should be the most accessible one. Let it be assumed that a mechanic is required to test or correct the timing of a four-cylinder, four-cycle vertical engine. He would have to know the order in which the cylinders fired, and how to find the firing center of No. 1 cylinder. As the operation of the valves on most motors may be readily seen, the firing center and the order in which the cylinders fire can be easily learned from the action of either set. For instance, if on turning the motor over slowly the intake valve of No. 1 cylinder opens and closes, then that of No. 3 cylinder, and following No. 3 that of No. 4 operates, the mechanic need go no further, for he knows that the engine fires 1-3-4-2. The exhaust valves, of course, may be used in the same way. However, if the valves are entirely enclosed, as on the Winton cars, open the priming or relief cocks, and beginning with cylinder No. 1 note the order in which the air is forced out through the cocks. There are two rules for finding which cylinder is on its firing center, that are based on the action of the valves; these are as follows: When an exhaust valve is open the following cylinder is about to fire. When an intake valve is open the previous cylinder is about to fire. One very simple method of finding the firing center of a cylinder is to open the priming cocks of all the cylinders but one, turn the motor over slowly till compression is encountered, open the cock, insert a stiff wire till it rests on the piston head, then carefully bring the piston to the top of its stroke. The cylinder will then be on its firing center. When the firing center, and the order in which the cylinders fire are known, all that remains to be done in timing an engine is to set the revolving segment of the commutator or distributer so that a spark will occur in the proper cylinder when the spark control lever is advanced about one-third or, with the spark control lever fully retarded, and the piston about ½ to 1 inch down on the explosion stroke, set the segment so that it just begins to make contact.

Many troubles arise from faulty or defective insulation.

A wire placed too close to an exhaust-pipe invariably fails after a time, owing to the insulation becoming burnt by the heat of the pipe.

A loose wire hanging against a sharp edge will invariably chafe through in course of time.

If the insulation of the coil breaks down it cannot be repaired on the road, it should be returned to the makers. A slight ticking is usually audible inside the coil when this occurs.

All wires where joined together should be carefully soldered, the joints being afterwards insulated with rubber or prepared tape. Never make a joint in the secondary wires. See that all terminals are tightly screwed up. When connecting insulated wire, the insulation must be removed, so that only the bare wire is attached. Wires sometimes become broken, and being loose make only a partial contact.

Battery terminals frequently become corroded; they should be covered with vaseline, and require periodical cleaning. See that all connections at the battery are clean and bright.

The porcelain of the spark plug may be cracked and the current jumping across the fracture. The points may be sooty and require cleaning. They may be touching and require separating, or they may be too far apart. The usual distance between the points is about one thirty-second of an inch, which is approximately the thickness of a heavy business card.

Clean all oil and dirt from the commutator. Most commutators are so placed as to give the maximum possible opportunity to collect oil and dirt. They should always be provided with a cover.

In course of time dry or storage batteries will become weak or discharged. Always carry an extra set.

Spanners, oil-cans, tire-pumps, etc., have been known to get on the top of the batteries, thereby connecting the terminals together and causing a short-circuit.

The platinum contacts of the coil may become corroded. They should be cleaned with a small piece of emery cloth or sandpaper.

Ignition, Atwater Kent. This device is designed to draw from a battery, as nearly as possible, only the electrical energy necessary to ignite the charge, and to keep the batteries until the energy remaining in them is too small to produce an effective spark. Its principal constituent parts are, a jump-spark coil and condenser, a primary contact maker, the time of which may be advanced or retarded, and a high tension distributer. Its distinguishing features are—

a. But one spark is made for each ignition.

b. The primary contact, rupture of which produces the spark, is exceedingly brief, no longer in fact than is actually required to build up the magnetism in the core of the spark coil.

c. The duration of this contact is independent of the engine speed in the same way that the contact of the ordinary coil vibrator is.

d. Contact is made and broken mechanically through a shaft driven by the engine, consequently a spark may be obtained from a battery that is too weak to operate a vibrator. The mechanism by which the instantaneous primary contact is produced is similar to a snap contact produced by a small spring-controlled hammer pulled out of position by a ratchet on the shaft. The ratchet has as many teeth as there are cylinders, and runs at the camshaft speed. When used with a two-cycle engine, it runs at the crankshaft speed if there are four cylinders. If there are two cylinders, it runs at half the engine speed and the ratchet has four teeth. The ordinary commutator is not used in connection with it, but a driving connection must be made from the crankshaft or camshaft to the vertical shaft of the spark generator itself, which is mounted on the back of the dashboard.

The Atwater-Kent system consists of three parts: 1, The unisparker, which combines the special form of contact-maker, which is the basic principle of this system, and a high tension distributor.

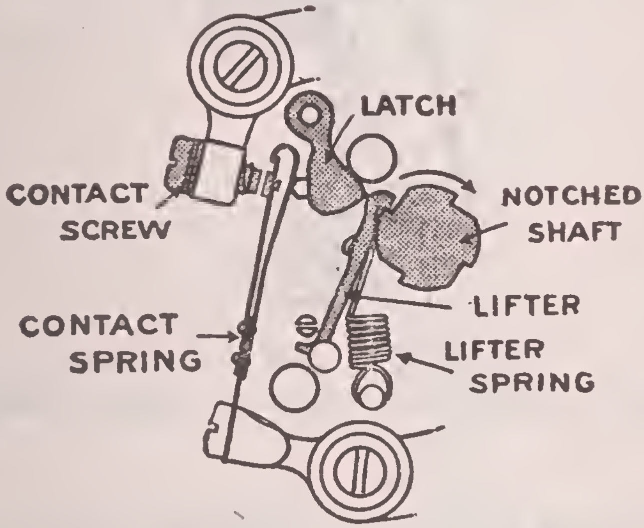


Fig. 164
Atwater Kent Timer Before Moving Lever

2, The coil, which consists of a simple primary and secondary winding, with condenser—all imbedded in a special insulating compound. The coil has no vibrators or other moving parts.

3, The ignition switch.

The operation of the unisparker is shown in Figs. 164 to 167. This consists of a notched shaft, one notch for each cylinder, which rotates at one-half the engine speed, a lifter or trigger which is pulled forward by the rotation of the shaft and a spring which pulls the lifter back to its original position. A hardened steel latch and a pair of contact points complete the device.

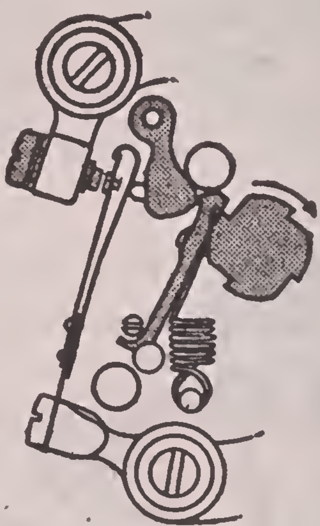


Fig. 165
Atwater Kent Timer Before Lever Escapes

The figures show the operation of the contact-maker very clearly. It will be noted that in Fig. 164 the lifter is being pulled forward by the notched shaft. When pulled forward as far as the shaft will carry it, Fig. 165, the lifter is suddenly pulled back by the recoil of the lifter spring. In returning it strikes against the latch, throwing this against the contact spring and closing the contact for a very brief instant—far too quickly for the eye to follow the movement, Fig. 166.

Fig. 167 shows the lifter ready to be pulled forward by the next notch.

Note that the circuit is closed only during the instant of the spark. No current can flow at any other time, even if the switch is left "on" when the motor is not running.

By means of the distributor, which forms the upper part of the unisparker, the high-tension current from the coil is conveyed by the rotating distributor block, which seats on the end of the unisparker, to each of the spark plug terminals in the order of firing.

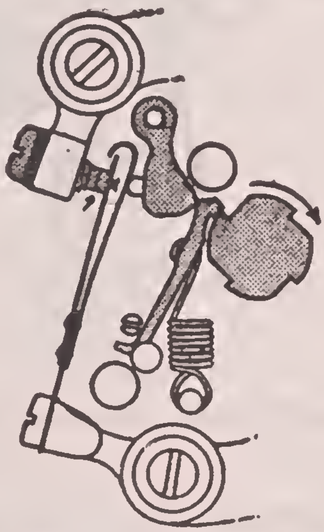


Fig. 166
Atwater Kent Timer With Contacts Closed

Where the lighting and starting battery is used for ignition, two wires from the ignition system should run directly to the battery terminals. They should not be connected in on any other branch circuit.

The automatic type is cylindrical in shape and consists of a pressed steel casing with a hard rubber cap, the latter forming the base of the high-tension distributor. The device is mounted on a shaft which is driven at half the speed of the crankshaft. Within the casing is located the mechanism, consisting of the governor which automatically controls the advance, the circuit breaker and high-tension distributor.

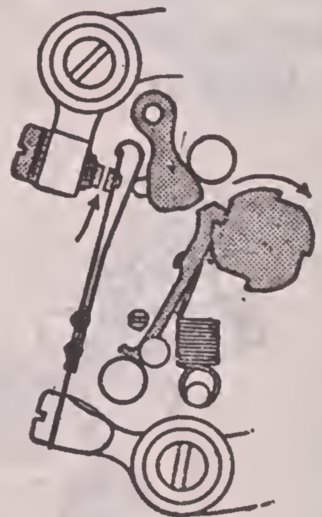


Fig. 167
Atwater Kent Timer With Contacts Re-opened

At the bottom of the casing is the governor, a modification of the centrifugal type which consists of two pairs of weights, each pair being pivoted together at their centers, and two double arm brackets. When the shaft starts to revolve, the weights extend away from the center and the arms change their angular relation in direct proportion to the speed of the driving shaft.

In order that the weights will not move away from the center too easily and give too great an advance to low speeds, the brackets carrying the springs are so arranged that the weights have to act against them when obeying the impulse of centrifugal force, and moving away from the axis of rotation. Virtually each weight is a bell-crank lever with one point of connection pivoted to the arm and the other point of connection pivoted to the weight. The four weights thus give four bell-crank levers working in the same direction at the same time against the four respective springs.

In timing with automatic advance the piston in No. 1 cylinder should be raised to high dead center, between compression and power strokes, then, with the clamp which holds the unisparker loose, the unisparker should be slowly and carefully turned backwards, or counter clockwise (contrary to the direction of rotation of the timer-shaft), until a click is heard. This click happens at the exact instant of the spark. Now clamp the unisparker tight, being careful not to change its position.

Now remove the distributor cap, which fits only in one position, and note the position of the distributor block on the end of the shaft. The terminal to which it points is connected to No. 1 cylinder. The other cylinders in their proper order of order of firing are connected to the other terminals in turn, keeping in mind the direction of rotation of the timer shaft.

When timed in this manner the spark occurs exactly on "center" when the engine is turned over slowly. At cranking speeds the governor automatically retards the spark for safe starting, and as the speed increases, the spark is automatically advanced, thus requiring no attention on the part of the driver.

The first operation in timing the hand advance unisparker is to crank the engine until the piston of No. 1 cylinder is on high dead center between the compression and power strokes.

The unisparker is then placed on the shaft, the advance rod from the steering post being connected to the lug on the side of the unisparker, which is provided for that purpose.

The position of the spark advance lever on the steering wheel sector should be within ½ inch of full retard, and the connecting levers should be such as to give the unisparker a movement of at least 45 degrees to 60 degrees for the full range of spark advance.

After the spark lever is connected up and the unisparker is in position it should be left loose at the driving gear, and, with the motor on dead center as above directed, the shaft of the unisparker should then be turned forward or in the same direction as that in which the timer shaft normally rotates, until a click is heard, at which point it should be set by tightening the driving connection.

The contact points are the only adjustable feature of the unisparker. These points should never touch when engine is at rest and the space between them should vary from 1/100 to 1/64 of an inch, depending upon the strength of the batteries, spark, heat required, etc The spark can be made hotter by decreasing the distance, and current can be economized by increasing it. Once or twice a season these contacts should be examined and should be kept flat and bright by means of a small file or emery cloth on a stick. The proper adjustment when starting with new batteries is about 1/32 of an inch, if dry cells are used. If storage battery is used, it may be necessary to reduce this a little. At intervals of six or eight hundred miles of service as the batteries decrease in strength, these contacts should be closed from a quarter to a half turn, or until regular firing is obtained. Do not attempt under any circumstances to adjust the tension of the springs.

Frequently when high-tension wires are run from the distributor to the spark plugs through metal or fibre tubing, trouble is experienced with missing and back-firing, which is due to induction between the various wires in the tube. This trouble is especially likely to happen if the main secondary wire from the coil to the center of the distributor runs through this tube with the spark-plug wires.

Wherever possible, the distributor wires should be separated by at least ½ inch of space and should be supported by brackets or insulators rather than run through a tube. In no case should the main distributor wire be run through a conduit with the other wires.

If irregular sparking is noted at all plugs, examine first the battery and connection therefrom. If the trouble commences suddenly, it is probably due to a loose connection in the wiring. If gradually, the batteries may be weakening or the contact points may require attention. See that the contacts are clean and bright, and also that the moving parts are not gummed with oil or rusted.

Atwater Kent Closed Circuit System. The construction of an Atwater Kent breaker which operates on the closed circuit principle is shown in Figure 168.

The contact carrying arm is short and light and is acted upon at its free end by the cam, rather than at the center as is the more usual practice. The condenser has been mounted on the breaker base in place of in the coil as with some former installations, thus eliminating some of the outside wiring.

The distributor does not differ in principle of operation from former types. The distributor rotor just clears the points with which the spark plug wires connect and the high tension current jumps this minute gap.

The coil used with this system consists of the usual core with primary and secondary windings which are sealed into an insulating tube. On top of the coil is located a small length of iron wire, called the resistance unit, which is in series with the primary ignition circuit. With excessive flow of current because of the switch being left closed while the engine is idle or for any other reason, this wire heats and increases its resistance sufficiently to prevent a damaging heat at the breaker contacts or in the coil windings.

The gap between the contact points of the

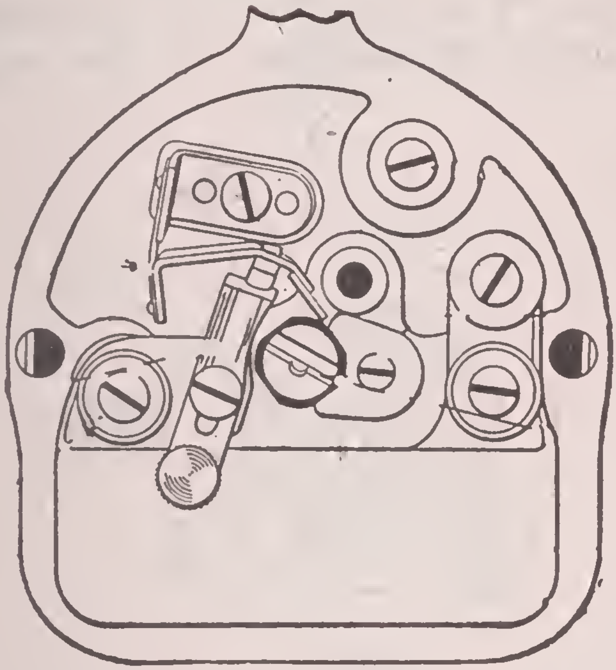


Fig. 168
Atwater Kent Closed-Circuit Breaker

breaker may be adjusted by sliding the bar which carries one of the contact points. This bar is held by a screw and with this screw loosened the necessary change may be made. The normal gap between the points with the end of the contact arm on the high point of a cam lobe should not be greater than six thousandths of an inch.

Ignition, Connecticut. The Connecticut automatic igniter system, Fig. 168, produces a single spark upon a break occurring in the primary circuit which, though being closed, has energized a coil. This break is effected in the igniter by means of a cam revolving against a breaker arm. The high tension spark is distributed in the same instrument. The igniter is mounted on a vertical shaft running at half engine speed irrespective of the number of

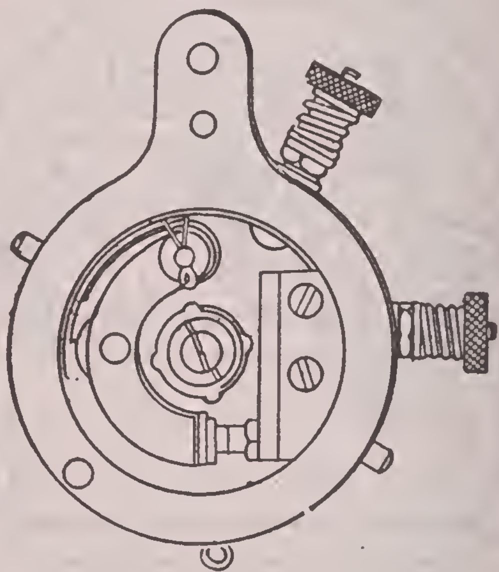


Fig. 169
Connecticut Breaker Mechanism

cylinders. The breaker arm is insulated from the base. This provides a metallic circuit; or in other words, no engine ground need be utilized in the primary or battery circuit, as the primary winding is insulated from the secondary ground in the coil. In this case there is no possibility of the ignition being affected through grounding or shorts in any other circuit of the car, such as disarrangement in lighting or starting systems.

The igniter may be taken apart and reassembled without the aid of any tools. The distributor case can be removed by unsnapping the two spring clips on the side, thus exposing the distributor arm carrying the carbon brush, Fig. 169, which can be slipped off the shaft.

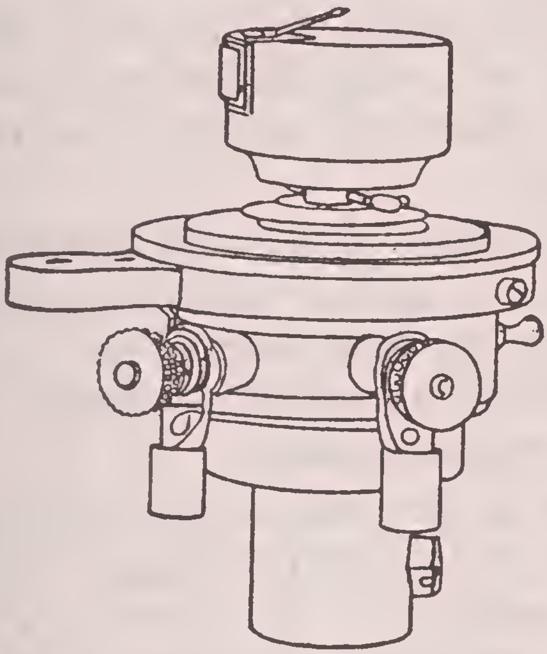


Fig. 170
Connecticut Distributor Rotor

Then remove cotter pin passing through shaft and the dust proof cover carrying the upper bearing can be taken off and the breaker box complete, Fig. 170, can be lifted from the shaft. As the shaft is not disturbed the timing is in no way affected when the igniter is reassembled on the shaft.

The system is not recommended for use on dry cells except as an emergency, but is designed to operate from a storage battery charged by a dynamo.

The automatic switch of the Connecticut automatic igniter system is a feature that is individual to this system and unique in ignition apparatus. Its function is to kick off the switch should the primary circuit be closed an unwarranted length of time, as in the case of a car being left with the switch on the engine stopped. This will prevent the draining of batteries.

Another purpose is to protect the ignition wiring should a disarrangement occur in the lighting or starting circuit and an excessive and destructive amount of current be introduced into the ignition circuit.

The circuit is closed in the automatic switch through contacts of the plunger type. These plungers are held in contact by a slotted locking plate. This plate is released by the "off" button on the switch; or in cases of prolonged or excessive flow of current, by a vibrating magnetic release thermostatically effected. The construction is such that no amount of outside vibration or jar can in any way affect the locking plate.

This automatic "kick off" is accomplished thermostatically and is a mechanism that has been employed for many years in telephone switches.

To time the igniter, turn the engine over, with petcocks open, until the piston of the first cylinder has reached the top of the compression stroke. Now advance the spark lever on the steering wheel about three-quarters of the way. Remove distributor cap, then set the igniter on driving shaft with set screws loose, connect advance lever, turn hub of igniter on shaft in direction of rotation until contact points are just open, which is the point at which the spark takes place, then tighten the hub set screws. Replace the distributor cap, carefully noticing which segment of the distributor the brush is opposite, for this is the connection to the spark plug of No. 1 cylinder. Connect up the balance of the spark plugs in their firing order. After connecting all wires you are then ready to try out the ignition. Before cranking, fully retard your spark lever. To suit individual requirements, it may be necessary to slightly advance the igniter hub if greater speed is required, or slightly retard it for very slow speed.

This igniter is completely housed and protected. Little care is required to keep it in working condition. About every four or five thousand miles the distributor cap should be removed and wiped out. On the ball-bearing igniter, the distributor arm should be withdrawn and one or two drops and no more of good oil injected into the hole in the end of the shaft which carries the distributor arm.

This will lubricate the lower ball-bearing. No other parts need oiling. Care should be taken to see that oil does not reach the contact points. On the plain bearings or self-lubricating type, the bearings require no attention whatever.

The contact points will probably require no attention until run at least ten thousand miles and in some cases they may operate for over thirty thousand miles without attention.

The points do not require refiling or cleaning even though they may be very rough and irregular, but when they become so badly burned as to cause missing they should then be renewed, in which case proceed as follows:

Remove the distributor cap and arm, disconnect advance lever and wires, remove cotter pin in igniter shaft, then spring washer and fibre washer, and lift the housing from its shaft.

The contact adjustment screw will be noticed under the dust ring, it being locked from turning by a hexagon nut on the screw inside near the end. Care should be taken to see that this nut is tightened up snugly after making a replacement or adjustment. When it is necessary to adjust these points they should be set so that when the roller rests on the point of the cam, they open about the same as a magneto interrupter. It is not necessary, however, to make this adjustment as accurately as on a magneto. The adjustable contact screw can be removed by taking off the lock-nut and then screwing it back out of the housing.

The contact on the breaker arm is riveted into it and a complete new arm is necessary in making a replacement.

This arm can be readily removed by taking out the small cotter pin in the end of the stud on which it moves, remove small fibre washers and the arm can then be lifted out.

When replacing the arm on the stud before putting the cotter pin in place, be sure and replace the little fibre washers which rest on the top of the arm just under the little cotter pin and the fibre washer on the stud in the bottom of the cup.

Ignition, Delco. The Delco system of battery ignition makes use of a combined breaker and distributor usually mounted on, and driven from, the lighting dynamo or motor-dynamo. In some installations the ignition unit is placed by itself, but the construction and operation is the same in either case.

The distributor and timer are driven through a set of spiral gears attached to the armature shaft or its extension. The distributor consists of a cap or head of insulating material, carrying one high-tension contact in the center, with similar contacts spaced equi-distant about the center, and a rotor which maintains constant communication with the central contact.

The rotor carries a contact button which sends the secondary circuit to the spark plug in the proper cylinder.

Beneath the distributor head and rotor is the timer, Fig. 171, which is provided with a screw in the center of the shaft, the loosening of which

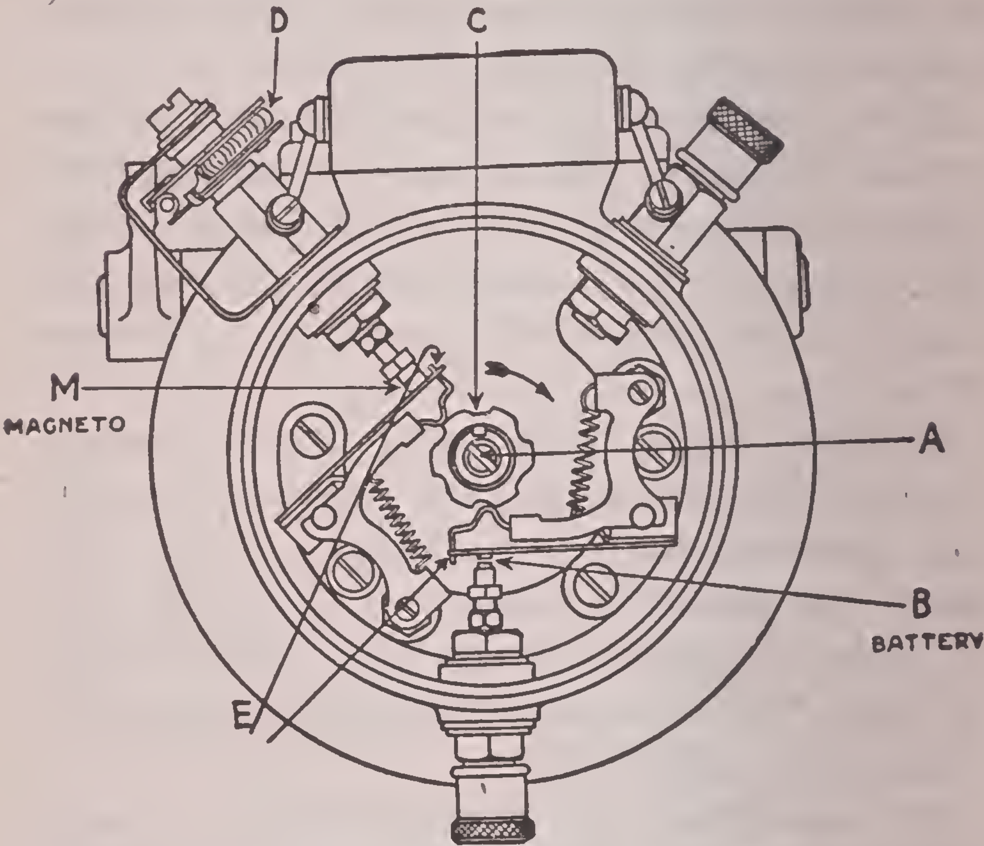


Fig. 171

Delco Ignition Head Breaker. A, Cam Holding Screw. B, Battery Current Contacts. C, Breaker Cam. D, Resistance Wire Spool. E, Cam Contact Levers. M, Dynamo Current Contacts.

allows the cam to be turned in either direction to secure the proper timing, turning in a clockwise direction to advance and counter-clockwise to retard.

The spark occurs at the instant the timer contacts are opened.

The adjustment screw must always be set down tight after the cam is adjusted.

The same weight which operates the arm on the regulating resistance also operates the automatic spark control. In addition to the automatic spark control, a manual spark control is provided, which is operated by the lever on the steering column, and is connected to the lever at the bottom of the motor generator. The manual spark control is for the purpose of securing the proper ignition control for variable conditions, such as starting, differences in gasoline and weather conditions. The automatic control is for the purpose of securing the proper ignition control necessary for the variations due to speed alone.

The resistance unit is a coil of resistance wire wound on a porcelain spool. Under ordinary conditions it remains cool and offers little resistance to the passage of current. If for any reason the ignition circuit remains closed for any considerable length of time, the current passing through the coil heats the resistance wire, increasing its resistance to a point where very little current passes, and insuring against a waste of current from battery and damage to the ignition coil and timer contacts. When the arm that cuts the regulating resistance into the shunt field circuit is at the top position (that is, at high speeds), the resistance unit is cut out of the ignition circuit. This increases the intensity of the spark at high speeds.

To time ignition: Fully retard the spark lever. Turn the engine so that upper dead center on flywheel is about one inch past dead center with No. 1 cylinder on the firing stroke. Loosen screw in center of timing mechanism and locate the proper lobe of the cam by turning until the button on the rotor comes under the high tension terminal for No. 1 cylinder. Set this lobe of the cam so that when the back lash in the distributor gears is rocked forward the timing contacts will be open, and when the back lash is rocked backward the contacts will just close. Tighten screw and replace rotor and distributor head.

If the motor fires properly on the "M" button, but not on the "B" button, the trouble must be in the wiring between the dry cells or the wires leading from the dry cells to the combination switch, or depleted dry cells.

If the ignition works on the "B" button and not on the "M" button, the trouble must be in the leads running from the storage battery to the motor-generator, or the lead running from the rear terminal on the generator to the combination switch, or in the storage battery itself, or its connection to the frame of the car.

If both systems of ignition fail and the supply of current from both the storage battery and dry cells is ample, the trouble must be in the coil, resistance unit, timer contacts or condenser. This is apparent from the fact that these work in the same capacity for each system of ignition.

The following directions for upkeep apply in a general way to the "M" or "Mag" ignition on all of the Delco systems, but do not apply to the dry battery ignition.

The contact points are of tungsten metal, which is very hard and requires a very high temperature to melt. These should be kept clean and smooth on the faces. This can be done by holding in a vice and using fine emery cloth held underneath a flat file. They should be so adjusted that when they are open they are apart ten-thousands of an inch and the contact arm should move about fifteen-thousands of an inch after the contacts close.

The most common causes of contact trouble are due to the following: (1) Resistance unit shorted out, resulting in excessive current through the contacts, especially at low speeds. (2) Abnormally high voltages due to running without the battery or with a loose connection in the battery circuit. (3) A broken down condenser.

The distributor head should be properly located, that is with the locating tongue of the hold-down clip in the notch on the distributor head. The head should be kept wiped clean from dust and dirt and in some cases it is advisable to lubricate this head with a small amount of vaseline.

The rotor should be kept free from dust and dirt and the rotor button polished bright. The rotor button should be fully depressed before putting on the distributor head to make sure the spring will allow the button to go down to the proper level and not subject it to undue pressure on the distributor head.

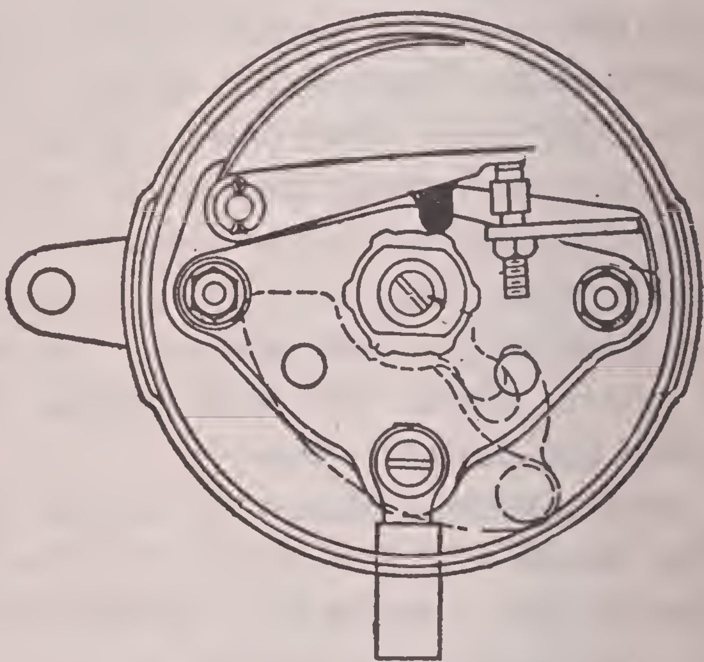


Fig. 172

Delco Closed Circuit System. The closed circuit type of breaker used in recently manufactured equipment is shown in Figure 172. The device consists of a straight arm fitted with a small bumper against which the lobes of the cam strike when the contacts are to be separated. The contacts are normally held closed by a long flat spring attached to the pivoted end of the arm.

The position of the cam may be altered for timing purposes by loosening the screw in its center which allows the cam itself to be turned about its shaft. One of the contacts is adjustable to secure the proper opening by turning the screw on which it is mounted. The adjustment is maintained by tightening a lock nut. The proper break of these contacts when held apart by the lobe of the cam is eighteen thousandths of an inch. During the first few hundred miles driving the wear of the fibre block on the breaker arm is much greater than after this block has worn to a seat. The contacts should be adjusted once or twice during the first season's operation of the car, after which but little attention will be required.

In setting the breaker cam for timing, the proper lobe of the cam should be located by turning, with the center screw loosened, until the distributor rotor comes under the position which number one high tension terminal on the distributor cover occupies when the cover is properly located. With number one piston at ignition top center this lobe of the cam should be set so that when the play of the driving gears is rocked forward the contacts will be open, and when rocked backward the contacts will just close.

Ignition, Remy Battery. This make of ignition equipment is furnished in two principal types, one of which might be called "magneto type" and the other one a "vertical ignition head."

The magneto type of battery equipment bears a very close resemblance to the breaker and distributor end of a separate unit magneto, being composed of a distributor having terminals for the spark plug leads and below the distributor a breaker exactly similar in construction to that with magnetos. In connection with this unit a two-way switch is used, giving either dry battery or generator as a source of ignition current. To transform the current to one of high-tension a separate coil is used.

This coil differs from ordinary coil construction inasmuch as both ends of the primary winding are insulated, so that, in the event of a ground occurring in the lighting or starting circuits, the ignition will be unaffected. The coil is provided with a safety gap as a further means of protection.

The coil is wound for six volts and is to be used in connection with a storage battery or with five dry cells. The coil is to be mounted on the crankcase within 6 or 8 inches of the breaker points as the condenser is incorporated in the coil and not on the generator. A special top plate is provided to securely hold coil in position.

The circuit breaker platinum points may be inspected by removing the Bakelite housing cover. The points should have a smooth, clean, flat surface at all times. The break, or gap, of these points should be from 15 to 20 thousandths of an inch. The circuit breaker may, if desired, be removed without the aid of tools.

The high-tension current is distributed to the spark plug cables by means of a hard carbon brush making contact with distributor segments. Neither distributor nor brush will require any attention whatsoever.

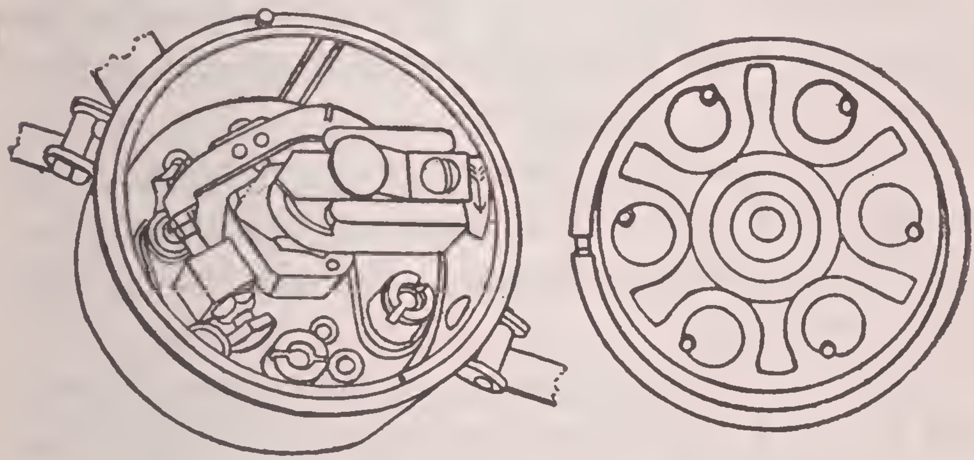


Fig. 173
Remy Vertical Ignition Timer

An oiler is provided for the distributor shaft,—only a few drops of light oil every one thousand miles will suffice.

The use of spark plugs which permit of the points being adjusted to a definite gap is recommended. The gap between the points should be from 20 to 25 thousandths of an inch.

If the motor misses when running idle or pulling light, the plug gaps should be wider. If motor misses at high speed or when pulling heavy at low speed, the plug gaps should be made closer.

The vertical ignition head consists of a combined breaker and distributor mounted in one case, Fig. 173, and adapted to be driven from a vertical shaft usually on or near the lighting dynamo.

Some of these distributors have a manual advance for the spark, while some are built with a mechanism which automatically advances the spark to meet the requirements of the engine upon which it is installed.

The high-tension current is distributed to the spark plug leads by a segment which revolves close to, but does not touch, the pins in the distributor head.

Either iridium-platinum, tungsten or silver is used in the contact points, the choice depending upon which is best suited to the installation.

The coil furnished with this system has a special ventilating base which may be bolted securely to the engine frame. Its current consumption is limited by a resistance located on top of the coil and which is in series with the primary winding.

The metal base of the coil makes an electrical connection with the engine or car frame for one side of the secondary winding. Therefore, it is very important before mounting the coil to see that all foreign matter, such as dirt, grease, paint, etc., is removed from the place where the coil is to be mounted. It is also very important that the base of the coil be fastened down securely at all times.

The switches furnished with this equipment are arranged to reverse the direction of current flow through the circuit breaker each time the ignition is used.

It is absolutely necessary that the ignition switch be placed in the "off" position when the engine is not running. If it is left in the "on" position, current from the storage battery will be dissipated in the ignition coil which, if continued, will exhaust the battery.

By an insulated system is meant one in which the circuit breaker is not grounded. By glancing at the wiring diagram it will be seen that the circuit from the switch around through the breaker box and back to the switch again is not grounded, and that the switch reverses the direction of the current flow through this circuit at each quarter turn.

If the insulation is worn off any one of the wires and the copper touches any of the metal parts of the car, a short circuit will result which will either render the system inoperative by burning out a fuse or will discharge the battery. A periodical inspection should be made of all wiring to see that it is not rubbing or chafing on any of the metal parts of the car and that all connections are tight and secure.

The contact screw should be adjusted with the wrench furnished with the system, so that the maximum opening of the points is .020 to .025 inch, or the thickness of the piece riveted upon the side of the wrench. The rebound spring should be at least .020 of an inch from the breaker arm when the points are at their maximum opening.

To obtain the best results the spark-plug gaps should be adjusted to .025 of an inch.

Ignition, Westinghouse. Dual ignition is obtained in the Westinghouse system; that is, the battery is an independent source of supply, as well as the generator operating with the battery, while the interrupter, ignition coil and distributer are common to both.

The interrupter is so constructed that the period of contact is practically the same at any speed. The spark voltage, therefore, does not fall off at high speeds, but is practically the same at all speeds.

Automatic spark advance is a feature of the Westinghouse generator. The automatic advance works over a range of 45°. Provision is made for manual operation also, and it is recommended that this be connected up, but the spark lever need not ordinarily be touched after the original adjustment, the automatic device taking care of all adjustments in running.

The interrupter is mounted on the generator shaft and contacts are operated by a centrifugal device that automatically adjusts the spark advance to the speed, keeps the period of contact nearly constant at all speeds and prevents any inequality between the two interruptions that occur in succession during each revolution.

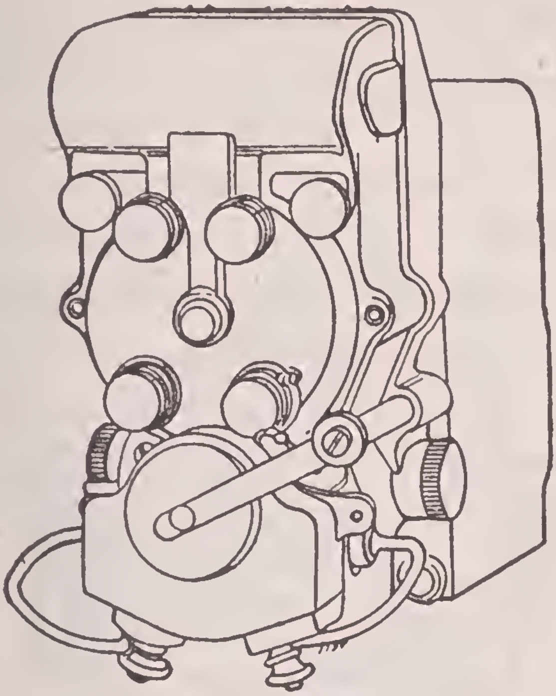


Fig. 174

Westinghouse Ignition and Lighting Dynamo

The ignition outfit consists, in addition to the lighting system and storage battery, of a distributer and an interrupter, which are made a part of the generator, Fig. 174, and an ignition coil and switch. The ignition coil transforms the six volts of the battery up to the high tension required for the spark plugs. The interrupter closes and then opens the ignition circuit at each half revolution of the generator shaft, and the distributer directs the high-tension current to each of the spark plugs in succession.

The operation of the ignition system, including the interrupter and distributer, ignition coil and switch, begins with the "making" of the primary circuit of the coil when the centrifugal weights push down the fibre bumper, allowing the interrupter contacts to close, Fig. 175. Then the weight moves off the fibre bumper, allowing the contacts to suddenly separate or open, when a high voltage is induced in the secondary of the ignition coil and directed by the distributer

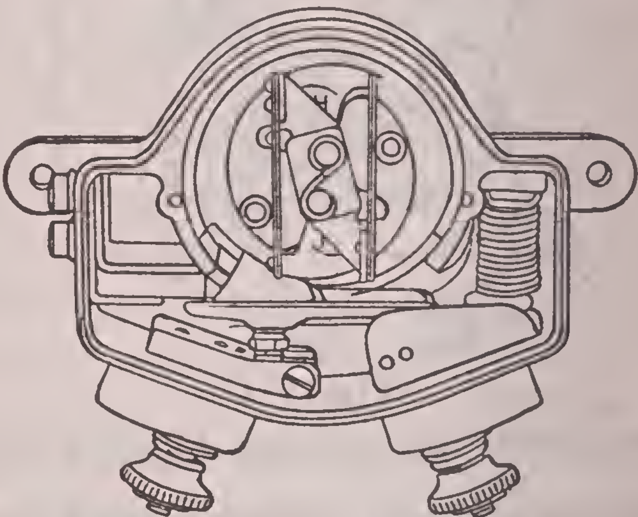


Fig. 175
Westinghouse Ignition Breaker, Low Speed Position

to the proper spark plug, causing a spark. As the speed of the engine increases, the weights are thrown out from the center and automatically advance the time of closing or opening the interrupter contacts, and hence advance the spark, Fig. 176. At the same time, due to their shape, they keep the contacts closed during a greater part of the revolution when running at high speed; this makes the period of contact practically the same at all speeds and prevents the spark voltage from falling off at high speeds.

To connect the ignition system to the circuit, insert the plug into the ignition switch and move the switch handle to the "on" position.

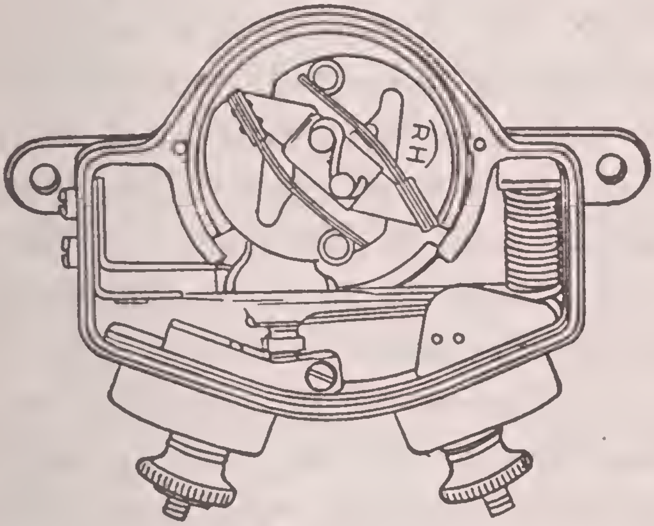


Fig. 176
Westinghouse Ignition Breaker, High Speed Position

In inserting the ignition plug pay no attention to the position of the brass contact pieces on the plug. It is desirable that the contacts will average up as often in one as in the other of the two possible positions, as this reverses the direction of the current through the interrupter contacts and greatly increases their life.

The spark plug should be set with slightly less than 1/32 inch between tips for best operation. Oily or carbonized plugs will often cause missing, and if dirty, they should be well brushed inside and outside with gasoline and wiped perfectly dry. A crack in the insulating material will, of course, probably lead to failure of spark in the cylinder.

The interrupter stop is adjusted so as to give the proper pressure on the bumper. When the engine is not running and the weights are in a closed position, there should be a space of 3/64 inch between the bumper lever and the stop. After the stop is adjusted, the contact screw should be adjusted by means of a wrench, so that with the cam lever against the upper stop, the contacts are open .005 inch. After setting for this separation, tighten the clamping screw so that the contact screw is held firmly. Be sure that the contacts open up positively and that the moving element moves clear up against the upper stop when released, with some spring tension still remaining to hold it in this position. See that the contacts are kept free from all oil and grit.

Interrupter weights should turn freely on their supporting pins and should also clear the centrifugal weight spring support by approximately .01 inch. They should show no lost motion between the two interlocking weights. In making any readjustments, be careful that when the engine is turned over very slowly by hand, both weights depress the moving part of the interrupter enough to definitely close the contacts, otherwise there will be a tendency to miss fire in every second cylinder, especially at low speeds and if the contacts are worn more or less.

When the weights are in the inner position, the springs should just touch the fibre-covered pins on the weights without exerting any appreciable pressure over that required to just positively return the weights to the innermost position. If necessary to adjust these springs, always bend the supporting arms and not the springs themselves.

Distributer brushes should slide freely in their holders and the springs should push them out so as to extend from the holder about ¼ inch when the distributer plate is removed from the generator. These brushes should, however, be retained firmly by their springs so as to never tend to fall completely out of the tubes. Be sure that both these brushes are in place in the distributer.

Distributer plate should be kept clean and free from carbon dust between brushes and contact surfaces by an occasional wiping. Any pitting of the distributer which is in advance of the contacts, indicates that the distributer gear is set one tooth or so too far back against the direction of its rotation. This may cause intermittent firing of the cylinders at the higher speeds, with consequent loss of power. The gear is set correctly at the factory, and if this setting is not disturbed the above trouble will not be encountered.

The distributer gear is meshed with the pinion on the generator shaft so that the mark at the edge of the gear lines up with the tooth of the pinion that is slightly beveled. In coupling the generator to the engine, place the piston of cylinder No. 1 on dead center at the end of the compression stroke. Remove the distributer plate and turn the generator back so that the line of the distributer brushholder block corresponds with the line on the end bracket. Couple the engine and generator shafts while in this position.

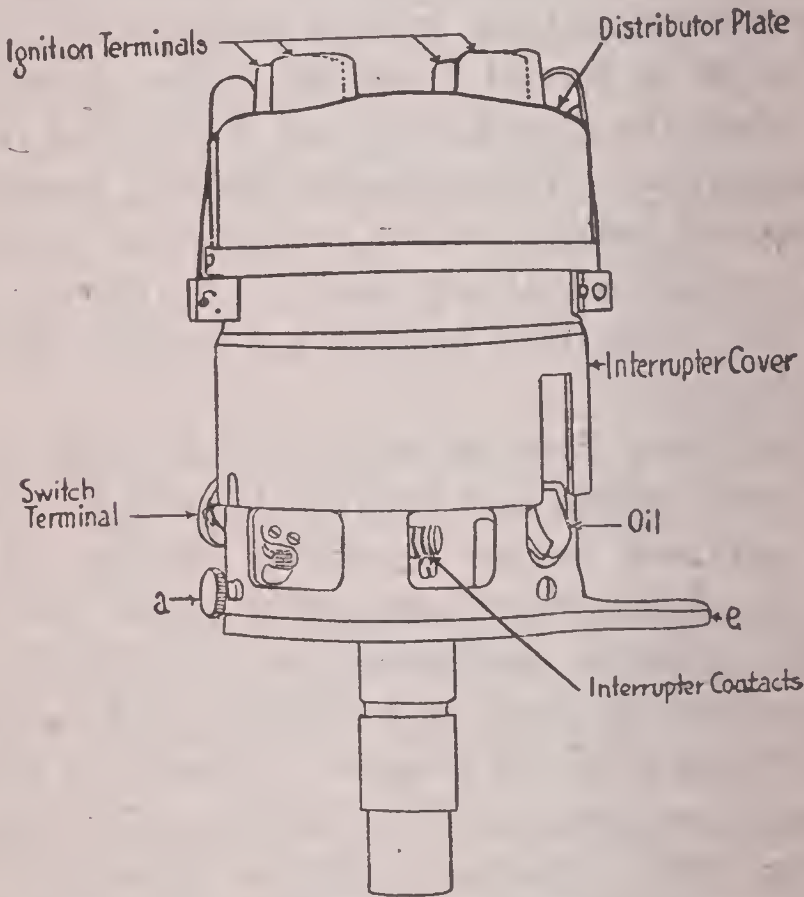


Fig. 177
Westinghouse Vertical Ignition Head

The Westinghouse vertical ignition unit can be used for ignition from storage batteries or plain lighting generators, Fig. 177. This set contains interrupter, spark coil and condenser, and distributer, all in one unit. One wire from the battery or generator to the ignition unit and one wire to each spark plug are all that are required.

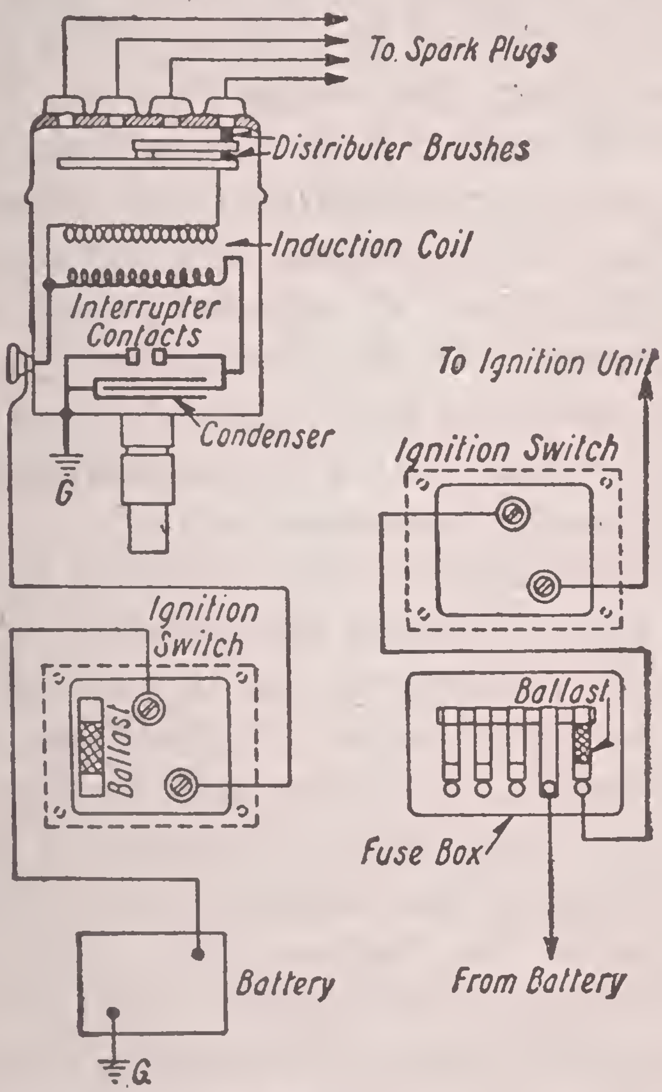


Fig. 178
Westinghouse Vertical Ignition Wiring

The interrupter, located at the lower end of the set, has the same type of circuit-breaker as that on the Westinghouse ignition and lighting generators, but no automatic spark advance feature. It can be used equally efficiently for either direction of rotation without change. The interrupter is enclosed by a spring collar which can be readily removed for inspection or adjustment of the contacts. The collar makes a tight joint and is clamped by a screw which prevents it from slipping. See wiring diagram, Fig. 178.

The Westinghouse Ford vertical ignition unit is made up of four essential parts, namely, the interrupter, the condenser, the induction coil, and the distributer, all included in one case.

The operation of the interrupter can be observed by loosening the thumbscrew and sliding upward the loose section of the insulation case, which forms the interrupter cover.

With the ignition switch turned to the "on" position and the engine turning over, each segment of the interrupter cam in turn passes on and off the fibre bumper. As each cam passes off the bumper, the interrupter contacts close, closing the circuit from the battery to the primary winding of the induction coil. Then as they pass on the bumper, the contacts are opened, suddenly opening the circuit, thus inducing a high voltage in the secondary of the induction coil. This voltage is directed by the distributer on the top of the ignition unit to the proper spark plug, causing a spark at the spark gap of the plug inside the cylinder, and igniting the charge therein.

The contact screw should be adjusted with a screwdriver so that, with the cam against the bumper, the contacts are open .008 inch.

If the contacts show pitted or irregular surfaces they should be smoothed up with a very fine file, making certain that the surfaces come together squarely after adjustment has been made.

Ignition, Magneto Type. Magneto ignition makes use of a separately mounted machine having its own armature and field magnets (permanent magnets) and being driven from the engine. A magneto always consists of a rotating member, this being a shuttle wound armature in most cases, or simply pieces of iron in the inductor type. This rotating member, through the change in the path of the lines of force from the magnets, produces a current in a coil separate or on the armature in the shuttle wound form, or mounted separately in the inductor magneto. This current rises from zero to its maximum voltage twice for each revolution of the magneto shaft, one impulse flowing in one direction through the windings and the next one (on the other half revolution) flowing in the opposite direction. The current from a magneto always reverses its direction in this way and is, therefore, an alternating current. The current from a lighting dynamo does not reverse its direction and is a direct current. For this reason no magneto can ever be used for charging a storage battery, a battery requiring current that always flows in one direction through the circuit.

Each of the current waves or alternations in the magneto circuit is utilized for the production of a spark; the breaker contacts opening at or near the time when the voltage and flow of current is at its maximum, thus producing a high pressure in the secondary circuit.

Combined with the armature and the permanent steel magnets that provide the field for the magneto is a breaker mechanism that interrupts the flow of current through the circuit whenever a spark is desired, and also a distributor that carries the contacts for delivering the high-tension current through the wires that lead to the spark plug in the cylinder that is ready to fire. While the details of construction of magnetos differ as described in the following pages, all types contain the parts described above. A shuttle wound armature with a breaker mounted on its shaft is shown in Fig. 179.

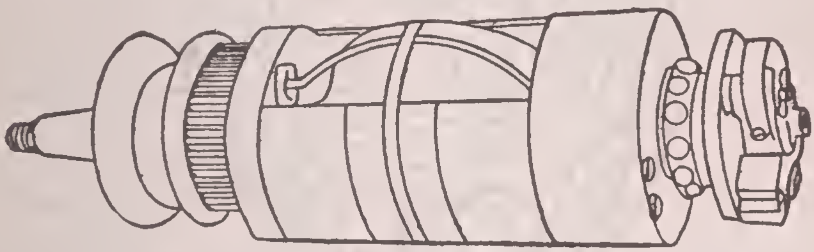


Fig. 179

Shuttle Type Magneto Armature With Breaker

The breaker may take any one of several forms, a commonly used construction being shown in Fig. 180. The circuit is completed through the contacts A, one of which is solidly mounted, and the other one attached to the movable arm B. The arm carries a fibre block that strikes a stationary cam when it is revolved on the armature shaft, and inasmuch as the arm is pivoted, the contacts are separated to interrupt the circuit and cause a spark to come from the winding of the high tension coil of the system. The fine winding that forms the high tension coil may be wound around outside of the armature winding on the shuttle type, or may be mounted in a housing separate from the magneto. With the high tension coil on the armature, the magneto is self-contained and produces a spark without outside parts, being called a true high tension magneto. Those magnetos using outside coils generate the current in their

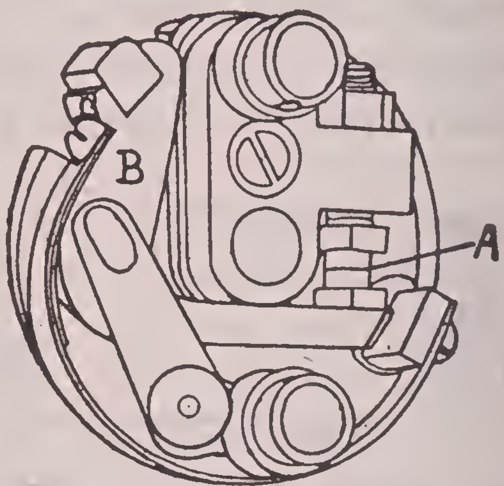


Fig. 180
Magneto Breaker

armature and send it through the heavy winding of the separate induction coil, or transformer coil. This separate coil has also a fine wire winding in which the high tension spark plug current is induced by the breaking of the circuit through the heavy wire when the breaker on the magneto opens.

The system known as "single ignition," when using a magneto, comprises a true high tension machine from which wires lead to the spark plugs. The only other wire required is one to the switch that will allow the driver to stop the production of sparks by connecting the armature winding to the frame of the car, or grounding it. No other source of current is provided with single ignition.

"Double ignition" provides a true high-tension magneto, as described, and in addition, a complete, and entirely separate, battery, timer and coil system with a separate set of spark plugs and wiring.

"Dual ignition" uses a magneto similar to the single ignition high-tension type, but provides an additional breaker and induction coil through which current may be led from a set of dry cells or a storage battery, thus providing a source of current other than that of the magneto armature when desired for starting or emergency use.

"Transformer coil ignition" makes use of a magneto that produces in its armature, or by inductor action, a current of low voltage that is led to a separately mounted transformer, or induction coil. The coil is connected by wires to the breaker and distributor on the magneto.

How to Remove and Replace a Magneto. When about to replace or remove a magneto it is well to see that all separable parts are properly marked, and if not, mark them. This may be done with a center punch, cold chisel, letters or numerals. In Fig. 181 is shown the guide marks generally used in connection with a high-tension magneto of a four-cylinder motor. The center punch marks C, on the Oldham coupling such as is usually employed on the magneto shaft between the magneto and its driving gear, serve as a guide in replacing the magneto. All that is necessary in replacing a high-tension magneto so marked on a four-cylinder, four-cycle motor is to see that the marks are directly opposite each other; but in two or six-cylinder motors, where the crankshaft and the armature of the magneto do not run at the same speed, care must be taken either not to move the crankshaft while the magneto is off or to check up the timing before it is replaced. In the same illustration is shown the method of mark-

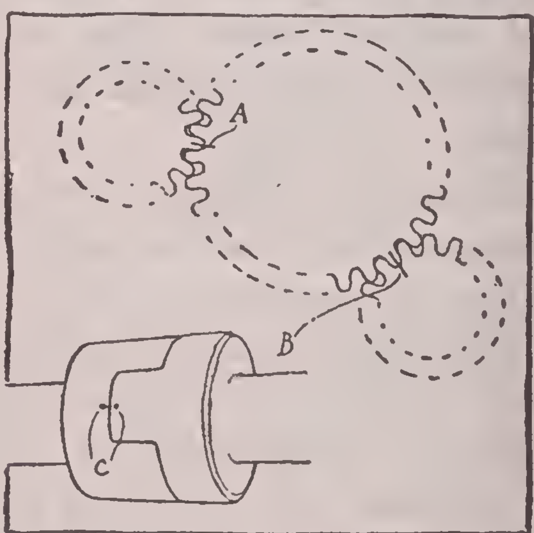


Fig. 181

ing the timing gears. These marks are made with a cold chisel and are generally present in up-to-date construction.

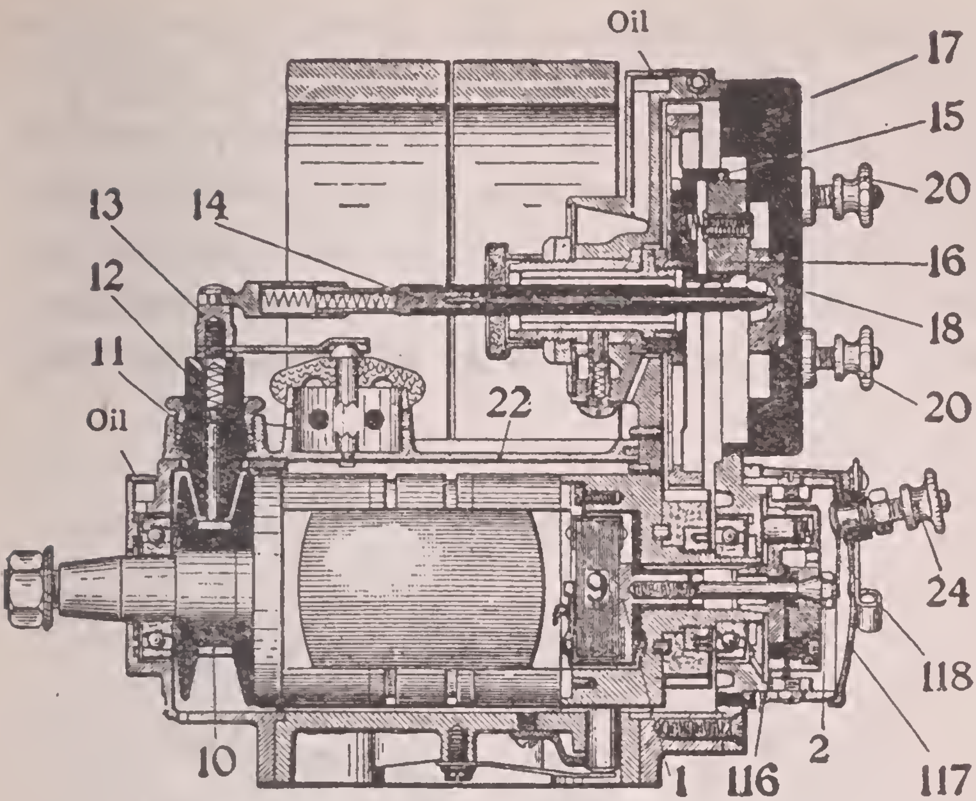


Fig. 182

Figs. 182 and 183

Bosch High Tension Magneto, Type "DU". 1, Armature End Plate for Primary Winding Connection. 2, Breaker Fastening Screw. 3, Breaker Contact Block. 4, Breaker Disc. 5, Long Platinum Contact Screw. 6, Short Platinum Contact Screw. 7, Flat Spring for Breaker Lever. 8, Breaker Lever. 9, Condenser. 10, Collector Ring for High Tension Current. 11, High Tension Carbon Brush. 12, Carbon Brush Holder. 13, Conductor Bar Terminal. 14, Conductor Bar. 15, Distributor Brush Holder. 16, Distributor Carbon Brush. 17, Distributor Plate. 18, Central Contact on Distributor. 19, Brass Segment. 20, Terminal for Spark Plug Wire. 21, Steel Breaker Cam. 22, Dust Cover. 24, Grounding Terminal. 25, Distributor Block Holding Spring. 116, Breaker Timing Lever. 117, Breaker Cover. 118, Conducting Spring for Grounding Terminal. 119, Breaker Cover Holding Spring.

Bosch Magnetos. The Bosch high tension magneto, Fig. 182, generates its own high-tension current directly in the armature winding and without the use of a separate coil or other apparatus. Apart from the cables connecting the magneto to the plugs, the Bosch high-tension magneto requires only one grounding wire.

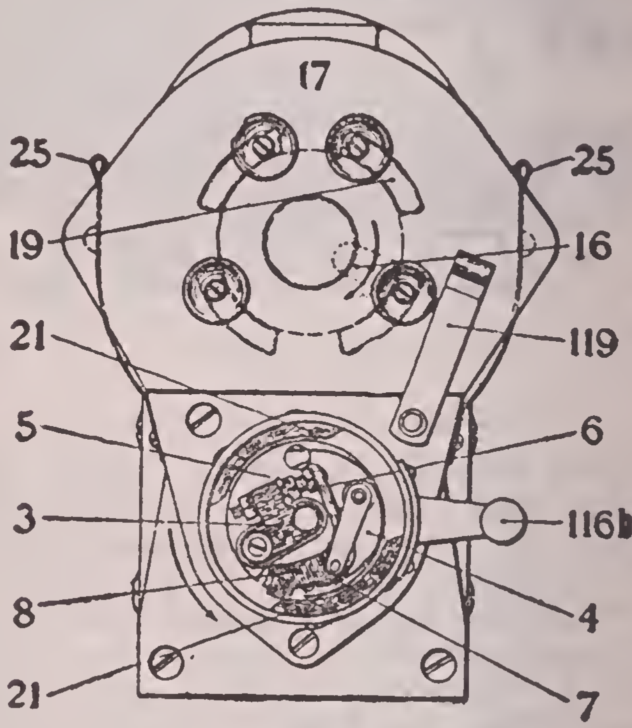


Fig. 183

The armature carries two windings. The primary consists of a few layers of heavy wire and the secondary of a great number of layers of fine wire. One end of the primary winding is grounded on the armature core, and the live end is brought out to a circuit-breaking device. The grounded end of the secondary winding is connected to the live end of the primary winding so that one is a continuation of the other.

During certain portions of the rotation of the armature the primary circuit is closed, and the variations in magnetic flux have their effect in inducing an electric current in it. When the current reaches a maximum, which will occur twice during each rotation of the armature, the primary circuit is broken, and the resulting armature reactions produce a high-tension current of extreme intensity in the secondary winding. This current is transmitted to a distributer by means of which it passes to the spark plug of the cylinder that is in the firing position.

The magneto interrupter, Fig. 183, is fitted into the end of the armature shaft which is taper-bored and provided with a key-way. The interrupter is held in position by a fastening screw, and may easily be removed. In replacing it, care should be taken that the key fits into the key-way and that the fastening screw is well tightened.

Twice during each revolution of the armature the primary circuit closes and opens, this being effected by the interrupter lever coming in contact with a steel segment, which is supported on the interrupter housing. When the magneto interrupter lever is not being acted upon by the steel segment, the platinum points are in contact, thus closing the primary circuit. Then as the armature rotates farther and the interrupter lever again comes in contact with a segment, the platinum points (interrupter contacts) open and thus interrupt the primary circuit. At the opening of the contact the ignition spark occurs instantaneously.

The distance between the platinum points when the magneto interrupter lever is fully depressed by one of the steel segments must not exceed 1/32 inch. This distance may be adjusted by means of a long platinum screw, and should be in accordance with the steel gauge that is pivoted to the adjusting wrench.

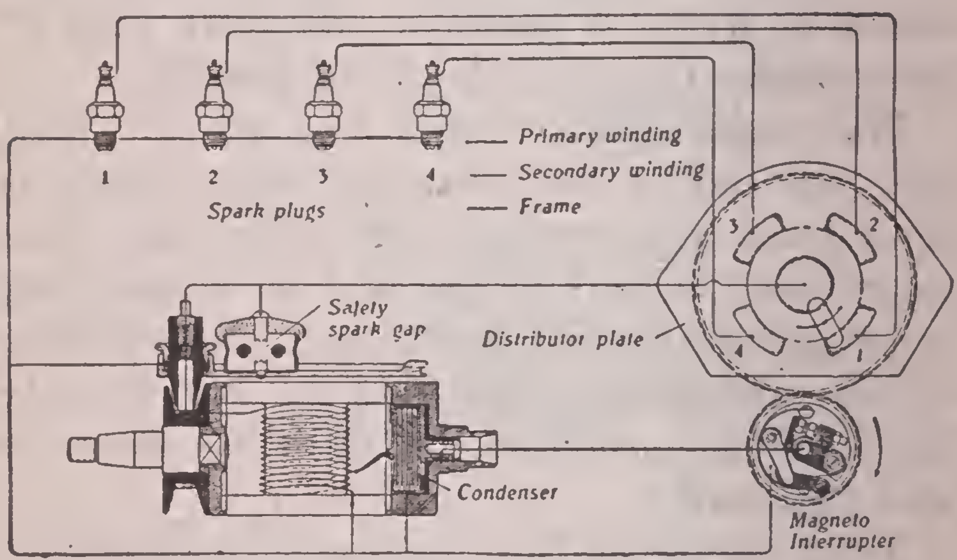


Fig. 184
High and Low Tension Circuits of Bosch Magneto

The connections of the magneto, Fig. 184, consist of a high-tension cable from the distributor to each spark plug, and a low-tension cable leading to the switch.

In order to protect the insulation of the armature and of the current-carrying parts of the apparatus against excessive voltage, a safety spark gap is arranged on the dust cover. It consists of a short pointed brass rod set on the dust cover, and a second pointed brass part supported a short distance from it in the center of the stealite cover of the housing. The insulated point is connected into the secondary circuit, and should there be any interference with the circuit normally provided through the spark plug the safety spark gap provides a point of discharge.

If a spark is observed passing in the safety spark gap it is an indication that there is an interruption in the regular secondary circuit, and the cause should be at once investigated.

A simple test for the magneto is to disconnect the grounding cable from grounding terminal and also to disconnect the spark plug cables. The motor should then be cranked briskly, and the safety spark gap closely observed. If sparks are seen at this point, it is an absolute indication that the magneto is in proper operating condition. If no sparks are observed it will be necessary to make sure that the primary circuit is properly interrupted by the magneto interrupter. Holding spring must be moved sideways, interrupter housing cover taken off, and it must be ascertained whether fastening screw is well tightened. After this it should be observed whether the platinum points are in contact when the steel cams are not acting on the magneto interrupter lever, also whether they separate the correct distance, 1/25th inch, when the interrupter lever is resting on one of the steel cams. Otherwise the distance must be adjusted by means of the platinum screw. The platinum contacts must be examined and any oil and dirt removed; in case the contacts are uneven (but only then) they must be smoothed with a fine flat file. If, after continued use, the platinum contacts are completely worn down, the two platinum screws must be renewed.

The Bosch dual magneto is of the standard Bosch type, and produces its own sparking current, which is timed by the revolving interrupter. The parts of this interrupter are carried on a disk that is attached to the armature and revolves with it, the segments that serve as cams being supported on the interrupter housing.

In addition, the magneto is provided with a steel cam having two projections, which is built into the interrupter disk. This cam acts on a lever that is supported on the interrupter housing, the lever being so connected in the battery circuit that it serves as a timer to control the flow of battery current through the coil.

It is obvious that the sparking current from the battery and from the magneto cannot be led to the spark plugs at the same time, and a further change from the magneto of the independent form is found in the removal of the conducting bar between the collecting ring and the distributer. The collecting ring brush is connected to the switch and a second wire leads from the switch to the terminal that is centrally located on the distributer.

When running on the magneto the sparking current that is induced thus flows to the distributer by way of switch contact. When running on the battery the primary circuit of the magneto is grounded, and there is, therefore, no production of sparking current by the magneto; it is then the sparking current from the coil that flows to the distributer connection. It will thus be seen that of the magneto and battery circuits the only parts used in common are the distributer and the spark plugs.

The end plate of the coil housing carries a handle by which the switch may be operated. By means of this switch either the magneto or the battery may be employed as the source of ignition current, and in its operation the entire coil is rotated within the housing. The inner side of the stationary switch plate is provided with spring contacts that register with contact plates attached to the base of the coil.

For the purpose of starting on the spark, a vibrator may be cut into the coil circuit by pressing the button that is seen in the center of the end plate. Normally, this vibrator is out of circuit, but the pressing of the button brings together its platinum contacts and a vibrator spark of high frequency is produced. It will be found that the distributer on the magneto is then in such a position that this vibrator spark is produced at the spark plug of the cylinder that is performing the power stroke; if mixture is present in this cylinder ignition will result and the engine will start.

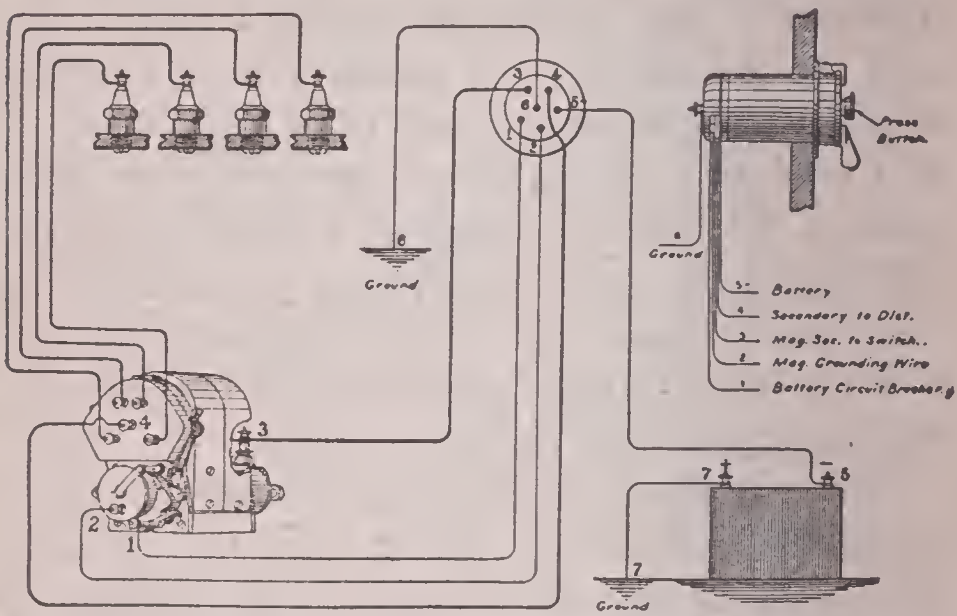


Fig. 185
Bosch Dual System Wiring Diagram

The dual system requires four connections between the magneto and the switch, Fig. 185; two of these are high tension and consist of wire No. 3 by which the high-tension current from the magneto is led to the switch contact, and wire No. 4 by which the high-tension current from either magneto or coil goes to the distributor. Wire No. 1 is low tension, and conducts the battery current from the primary winding of the coil to the battery interrupter. Low-tension wire No. 2 is the grounding wire by which the primary circuit of the magneto is grounded when the switch is thrown to the "off" or to the battery position. Wire No. 5 leads from the negative terminal of the battery to the coil, and the positive terminal of the battery is grounded by wire No. 7; a second ground wire No. 6 is connected to the coil terminal.

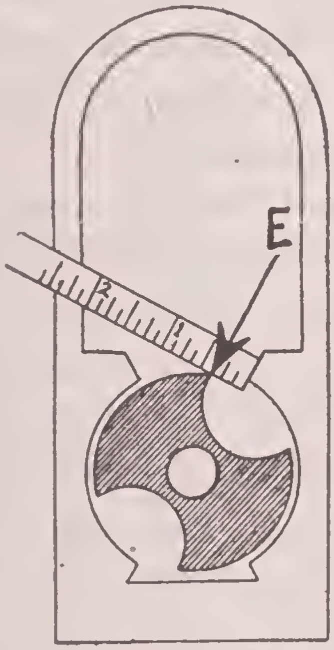


Fig. 186
Method of Setting Armature of Bosch Magneto

The timing of the Bosch Dual Magneto is identical with the standard type. The dual magneto is so arranged that the battery interrupter breaks its circuit approximately 10 degrees later than the magneto interrupter; this feature gives the full timing range of the magneto. With the timing lever fully retarded and the switch on the battery position, the battery spark will occur after the piston has passed dead center and is moving on the power stroke. The possibility of a back kick is thus eliminated.

The magneto should be placed in position on the bed plate or pad provided for it, the bolts or straps being properly secured; the driving gear or coupling, however, should be loose on the armature shaft. The dust cover, which is an aluminum plate located under the arch of the magneto, should then be removed, and this is accomplished according to the design of the various types of magnetos.

The engine should now be cranked until one of the pistons, preferably that of cylinder No. 1, is at the top of the compression stroke. With the engine in this position, the armature should be rotated by hand in the direction in which it will be driven until it is approximately in the position illustrated in Fig. 186. The setting of the armature is determined by the dimension marked E, Fig. 186, as follows:

"DU3" Model 4.............11 to 14 mm.
"DU4" Model 4.............13 to 15 mm.
"DU6" Model 4.............16 to 20 mm.
"DU3" Model 4............. 8 to 11 mm.
"DU4" Model 4.............10 to 13 mm.
"DU6" Model 4.............12 to 16 mm.

With the armature held in the proper position, the gear or coupling should be secured. The greatest care should be exercised to prevent the slipping of the armature during this operation.

In the fully enclosed magneto it is unnecessary to remove either the interrupter housing cover or the distributer plate in order to determine the setting of the instrument, or to locate the distributer terminal with which contact is made.

The magneto having been bolted into position, the crankshaft is to be turned to bring one of the pistons, preferably that of cylinder No. 1, to the firing position for full advance.

The armature is then rotated until the figure "1" can be seen through the window in the face of the distributer plate. The cover of the oilwell on the distributer end of the magneto is then to be raised, and the armature is to be turned a few degrees in one direction or the other until the red mark on one of the distributer gear teeth is brought to register with the red marks on the side of the window located between the two oil ducts.

The magneto is then in time for the full advance position, and the gear or coupling is to be secured to the armature shaft. Great care should be taken not to disturb the position either of the crankshaft or the armature shaft when fitting the driving member.

BOSCH ENCLOSED TYPES. In the "DU" dual magneto, the current is led from the collector ring connection to the coil and back to the distributer terminal that is located in the center of the distributer plate. In the enclosed dual magneto, this central terminal is eliminated, and the current is led internally to the distributer from a connection on the shaft end of the magneto. To expose this terminal, the shaft end bonnet should be removed, which is done by withdrawing the two screws in its lower flange, and sliding the bonnet backward. The terminal will then be seen to be a vulcanite post, with a boss that projects through a hole in the bonnet. In the top of this post are two vertical holes, in the bottom of each of which is a screw. These screws are to be withdrawn. The ends of the high-tension wires No. 3 and No. 4 leading to the coil are then to be cut off square, and after being led through the hole in the bonnet, are to be pressed to the bottoms of the slanting holes in the boss. The pointed screws are then to be replaced in the vertical holes, and in being driven home they will pierce the cables (and their insulation) and make the required connections. It is essential to use a screwdriver of the proper size, for a tool with too large a blade will inevitably crack the vulcanite. Great care must be taken to apply the screwdriver to the screws vertically in order to avoid cracking the vulcanite by side pressure. When the connections are made the bonnet is to be replaced.

Bosch Upkeep and Care. It will be noted that the press button on the coil is arranged to set in either of two positions, which are indicated by an arrow engraved on its surface, or projecting from its edge. When this button is in such a position that the arrow is pointing on the word "run" a single contact spark will be produced when the engine is cranked, or when the engine is running with the switch in the battery position. Under all ordinary conditions the button position should invariably be used.

When the engine is chilled, however, or under poor mixture conditions, starting can frequently be facilitated by pressing down the button and turning it slightly to the right so that the arrow is pointing to the word "start." This will lock the vibrator in circuit, and a shower of vibrator sparks will be produced in place of the single contact spark.

The platinum points of the magneto interrupter should be kept clean and smooth and so adjusted that they are open about 1/64 inch, or the thickness of the gauge attached to the adjusting wrench, when the magneto interrupter lever is wide open on one of the rollers or segments. It should not be necessary to clean or readjust these points oftener than once a season, and it is not advisable to readjust them until their condition and the missing of the engine show it to be absolutely necessary.

Each coil is stamped with the voltage of the battery current for which it is wound, and if this voltage is not exceeded the platinum contacts of the battery interrupter will not require attention for long periods. When this battery interrupter lever is being operated by the rollers or segments, the platinum points should be slightly wider open than the contact points of the magneto interrupter—the proper distance being about 1/50 inch.

If the magneto is at fault, all the cables and terminals should be examined for improper connections. The coil and battery system may then be disconnected by removing the wires from terminals Nos. 3 and 4 of the magneto, and with a short piece of wire magneto terminal No. 3 may be connected directly with magneto terminal No. 4. This will conduct the high-tension current induced in the magneto direct to the distributer. The grounding wire should then be disconnected from terminal No. 2 of the magneto. With this arrangement it should be possible to start the engine on the magneto, and it will be necessary to follow this plan should any accident happen to the coil.

To ascertain if the magneto is generating current, the grounding wire should be disconnected from terminal No. 2 on the magneto, and the high-tension wire should be disconnected from the collecting ring terminal No. 3. If the engine is then cranked briskly a spark should appear at the safety spark gap that is located under the arch of the magnets on the dust cover, provided the magneto is in proper condition. The grounding wire should then be reconnected to terminal No. 2, and the engine cranked. If no spark appears at the safety spark gap, the trouble may be determined as a leakage of the primary magneto current to ground by chafed insulation, incorrect connections, or an injury to the switch parts.

The coil may be tested by disconnecting wire

No. 4 from the magneto and throwing the switch to the battery position, operating the press button with terminal No. 4 3/16 inch from the metal of the engine. If the coil is in good condition, a brilliant spark should be observed. If the spark does not appear the test should be repeated with wire No. 3 disconnected. If the fault persists the coil body may be removed from the housing by withdrawing the holding screw that is located close to the supporting flange; the switch should then be unlocked and the end plate given a quarter revolution. This will release the bayonet lock and the coil body may then be withdrawn to permit the inspection of the switch contacts both of the coil and of the stationary switch plate. It may be that the spring contacts are bent or otherwise in bad condition. The withdrawing of the coil body and its handling should be performed with extreme care. No work should be done on the coil in the way of withdrawing screws, etc., and if the inspection does not disclose the fault the coil should be returned to its housing and the whole returned to the makers or to one of their branches.

Bosch "NU" Magneto. Like other Bosch high-tension magnetos, the type "NU4," Fig. 187, generates its own high-tension current directly in the magneto armature (the rotating member of the magneto) without the aid of a separate step-up coil, and has its timer and distributer integral. The distinct gear-driven distributor common to other types has been omitted in the "NU4" magneto, and in its stead is a double slipring combining the functions of current collector and distributor.

The armature winding is composed of two sections: one, primary, or low tension, consisting of a few layers of comparatively heavy wire, and the other, secondary, or high tension, consisting of many layers of fine wire.

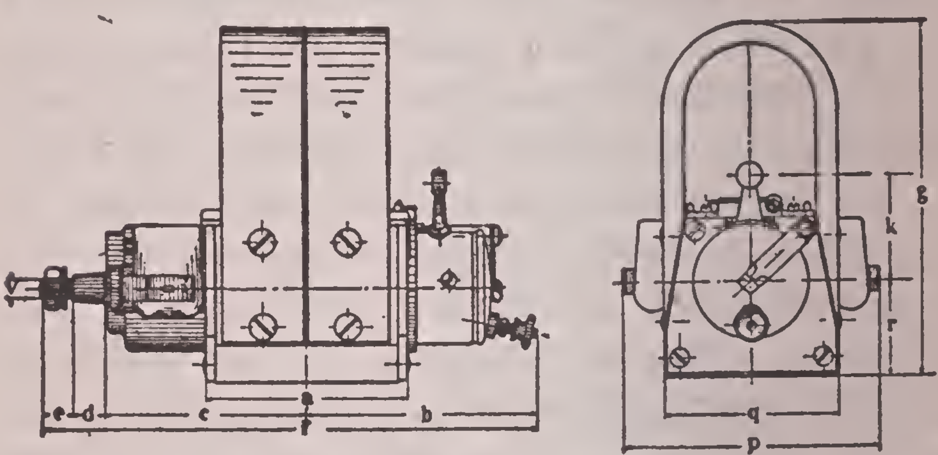


Fig. 187
Bosch High Tension Magneto, Model "NU"

The beginning of the primary winding is in metallic contact with the armature core, and the other, or live, end is connected by means of the interrupter fastening screw to the insulated contact block supporting the long platinum screw on the magneto interrupter. The interrupter lever, carrying a short platinum screw, is mounted on the interrupter disc which, in turn, is electrically connected to the armature core. The primary circuit is completed whenever the two platinum interrupter screws are in contact and interrupted whenever these screws are separated. The separation of the platinum screws is controlled by the action of the interrupter lever as it bears against the two steel segments secured to the inner surface of the interrupter housing. The high-tension current is generated in the secondary winding only when there is an interruption of the primary circuit, the spark being produced at the instant the platinum interrupter screws separate.

The secondary winding is insulated from the primary, and the two ends of the secondary are connected to two metal segments in the slipring mounted on the armature, just inside the driving shaft end plate of the magneto. The slipring has two grooves, each containing one of the two metal segments. These segments are set diametrically opposite on the armature shaft, that is, 180 degrees apart, and insulated from each other, as well as from the armature core and magneto frame.

The four slipring brushes which are part of the secondary circuit are supported by two double brush holders, one on each side of the driving shaft end plate, each holder carrying two brushes so arranged that each brush bears against the slipring in a separate groove. Upon rotation of the armature, the metal segment in one slipring groove makes contact with a brush on one side of the magneto at the same instant that the metal segment in the other slipring groove comes into contact with a brush on the opposite side of the magneto. The marks 1 and 2 appearing in white on both brush holders indicate pairs of brushes receiving simultaneous contact, those marked 1 constituting one pair, and those marked 2 the other.

A spark is caused at two plugs simultaneously. It is important to note that as two of the four slipring brushes receive contact simultaneously and each is connected by cable to the spark plug in one of the cylinders, the secondary circuit always includes two plugs, and the spark occurs in two cylinders simultaneously.

After removing one of the brush holders to permit observation of the slipring, the armature shaft is rotated in the direction in which it is to be driven, until the beginning of the metal slipring segment is visible in the slipring groove corresponding to Fig. 1 of the brush holder which has been removed. With that done, the cover of the magneto interrupter housing is to be removed to expose the interrupter. The armature shaft should then be further rotated until the platinum interrupter screws are just about to separate, which occurs when the interrupter lever begins to bear against one of the steel segments of the interrupter housing.

The armature should be held in that position while the magneto drive is connected to the engine, due care being taken that the piston of No. 1 cylinder is still exactly on top dead center of the compression stroke.

After the brush holder and interrupter housing cover have been replaced the installation is completed by connecting the cable of one of the brushes, marked 1, with cylinder No. 1, Fig. 188, and the other with cylinder No. 4; the remaining two cables, leading from the brushes, marked 2, must be connected with cylinders Nos. 2 and 3.

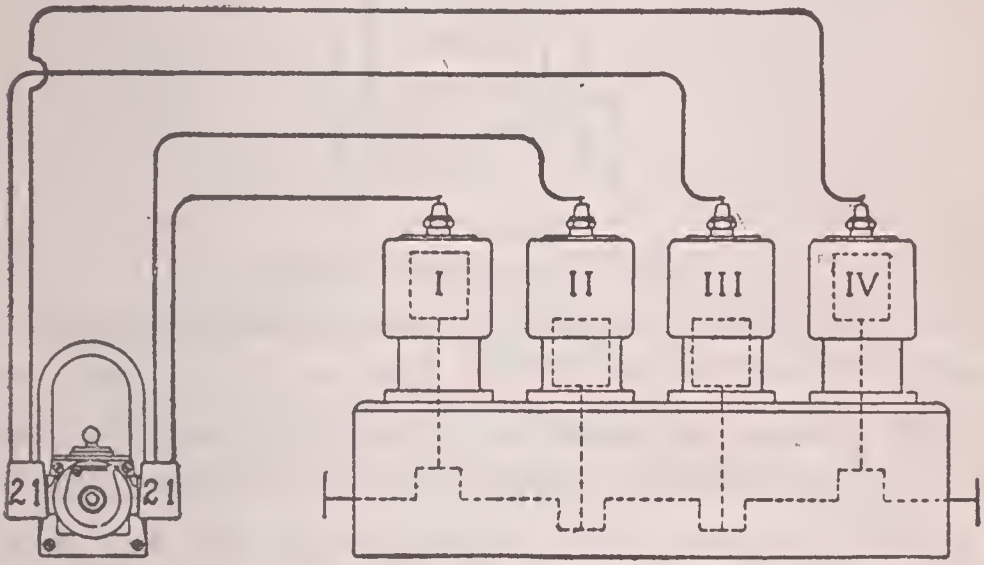


Fig. 188
Wiring Connections for Bosch Magneto, Model "NU"

DIXIE MAGNETO. The Mason principle on which the Dixie magneto operates is shown in Fig. 189. The magnet has two rotating polar extremities, N S, which are always of the same polarity, never reversing. These poles are in practical contact with the inner cheeks of the permanent magnet M, all air gaps being eliminated. Together with the U-shaped magnet, they form a magnet with rotating ends.

At right angles to the rotating poles is a field consisting of pole pieces F and G, Fig. 190, carrying across their top the core C and the windings W. When N is opposite G, the magnetism flows from pole N on the magnet to G and through the core C to F.

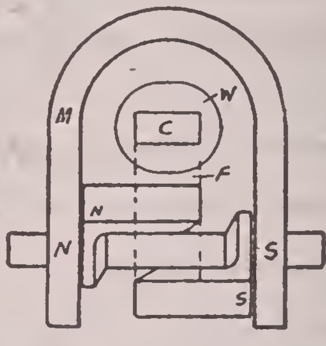


Fig. 189
Dixie Magneto Principle

In Fig. 191 the pole N has moved over to F and the direction of the flow of magnetism is reversed; it now flowing from F through C to G. The rotating poles do not reverse their polarity at any time, consequently the lag due to the magnetic reluctance in this part is eliminated.

The magneto has a rotating element consisting of two pieces of cast iron with a piece of brass between them, but no armature of the usual form, the revolving generating element being shown in Fig. 192. The pieces N S are separated by the brass block B and correspond to the pieces N S in Figs. 189, 190 and 191. The generating windings are carried on a small coil placed across the upwardly projecting ends of two pole pieces.

The core of the coil A, Fig. 193, is stationary, and the inner end G of the primary winding P is grounded on the core. Q indicates the metal frame of the machine, which is put to-

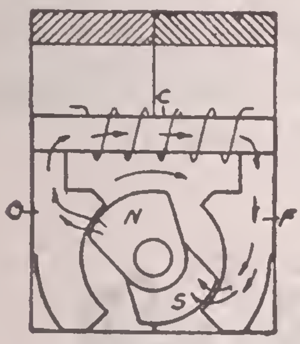


Fig. 190
Dixie Magneto Action

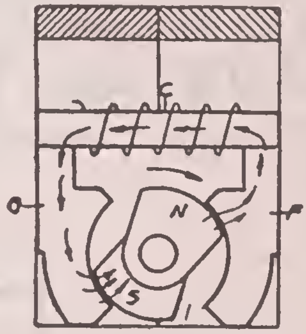


Fig. 191
Reversal of Magnetism Through Dixie Magneto

gether with screws. The condenser R is located immediately above the coil and is readily re-

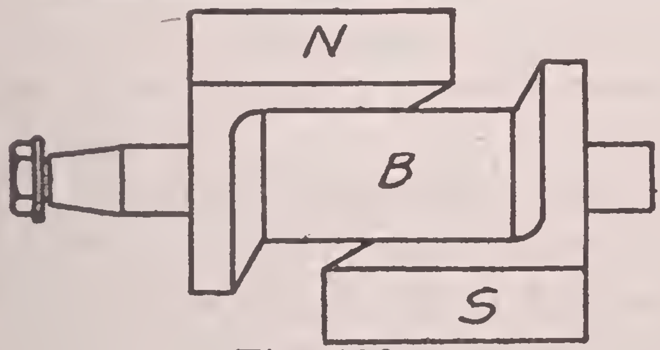


Fig. 192
Rotating Element in Dixie Magneto

movable. The terminal D is a screw on the head of the coil and the wire Z connects directly to the contact Y of the breaker. The breaker contacts are stationary and do not revolve as in the armature type.

Fig. 194 shows the high tension circuit. Here the end C of the high tension winding goes to a metal plate D carried on the upper side A of the coil. Against D bears a connection F, which is practically one piece with the traveling contact J, which connects to the spark plug segment L, the circuit being completed through the spark plug, engine frame and frame of magneto in the usual manner without brush G.

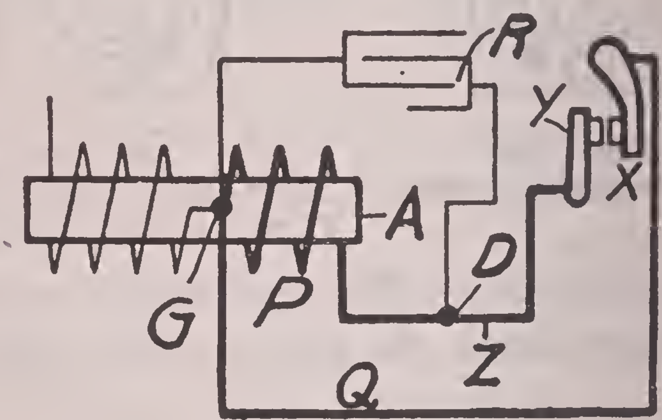


Fig. 193
Low Tension Primary Circuit of Dixie Magneto

The proper distance between the platinum points when separated should not exceed 1/50 of an inch, and a gauge of the proper size is attached to the screwdriver furnished with the Dixie.

The platinum contacts should be kept clean and properly adjusted. Should the contacts become pitted, a fine file should be used to smooth them in order to permit them to come into perfect contact. The distributor block should be removed occasionally and inspected for an accumulation of carbon dust. The inside of the distributor should then be wiped dry with a clean cloth. When replacing the block, care must be taken in pushing the carbon brush into the socket. The magneto should not be tested unless it is completely assembled, that is, with the breaker box, distributor cover and wires in position.

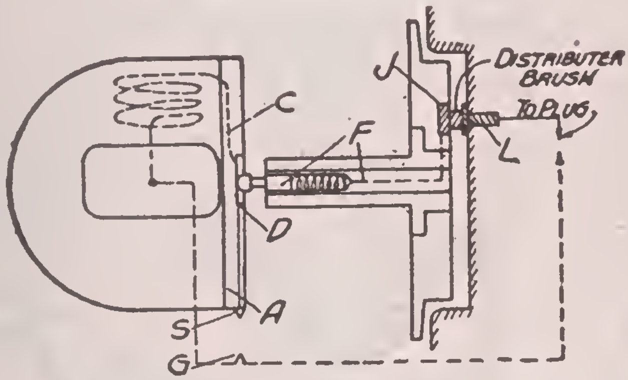


Fig. 194
High Tension Circuit of Dixie Magneto

In order to obtain the most efficient results with the Dixie magneto the normal setting of the spark plug points should not exceed .025 of an inch and it is advisable to have the gap just right before a spark plug is inserted into the cylinder. The spark plug electrodes may be easily set by means of the gauge attached to the screwdriver furnished with the magneto.

Eisemann Magnetos. Recent models of Eisemann magnetos have been designated as the G4 type. The breaker of the first G4 instruments is shown in Figure 195. Its cam is stationary except for the movement in advance and retard, while the breaker arm and contact carrying parts are carried by the armature shaft and revolve around the cam. The moving contact point is

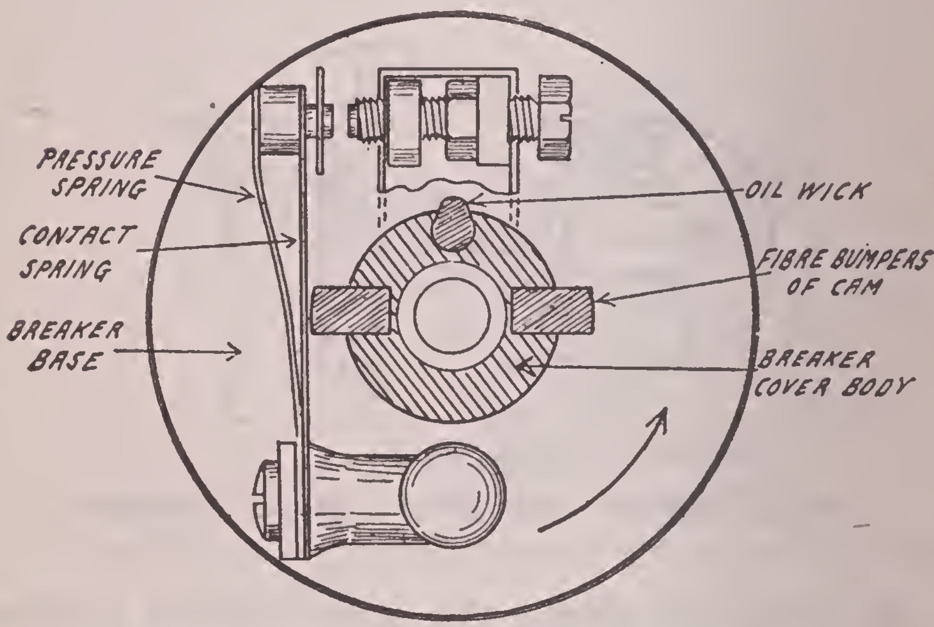


Fig. 195

carried at the end of a flat contact spring. Back of the contact spring is a pressure spring which serves to hold the contacts closed when not being acted upon by the cam.

A later breaker mechanism is shown in Figure 196. This breaker is similar to the design used on some of the older models and might be taken as typical of many true high tension magnetos. The cams are stationary in the circumference of the housing, while the contact arm and fixed contact carrying parts are attached to the end of

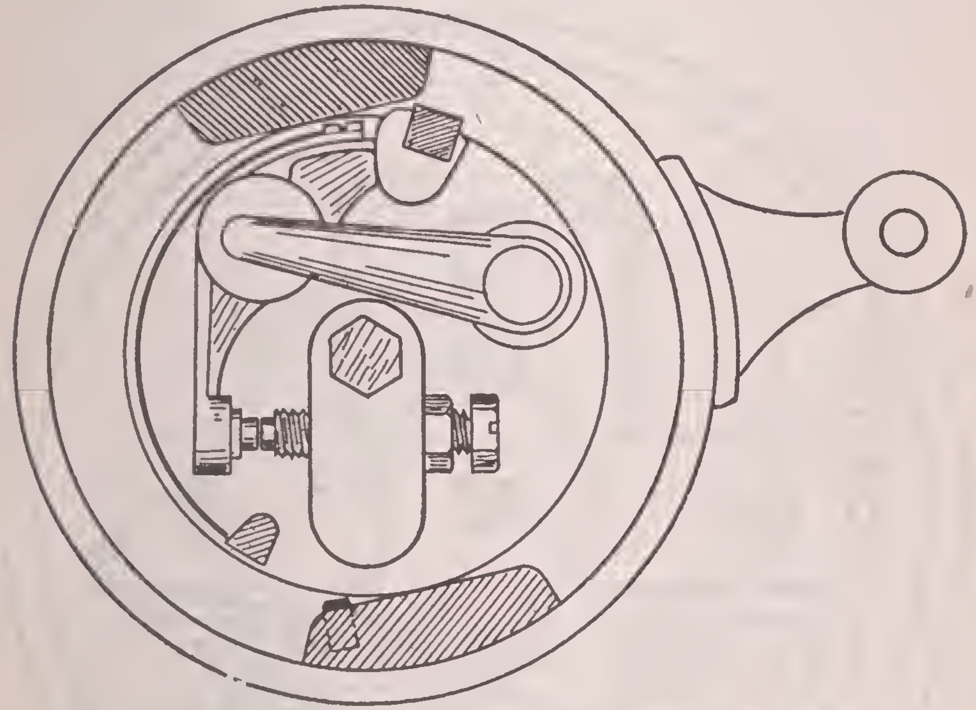


Fig. 196

the armature shaft and revolve with it. The breaker housing and cam are rotated to secure advance and retard.

The armatures of these magnetos are of the conventional shuttle type. The distributors are of the wipe contact type having a metal segment set into the rotor, this segment revolving past a series of carbon brushes set into the cover. A safety spark gap is provided by means of one or two small brass screws which pass through the armature housing and have their inner ends extending to within about 3/8 of an inch of the collector ring on the armature shaft.

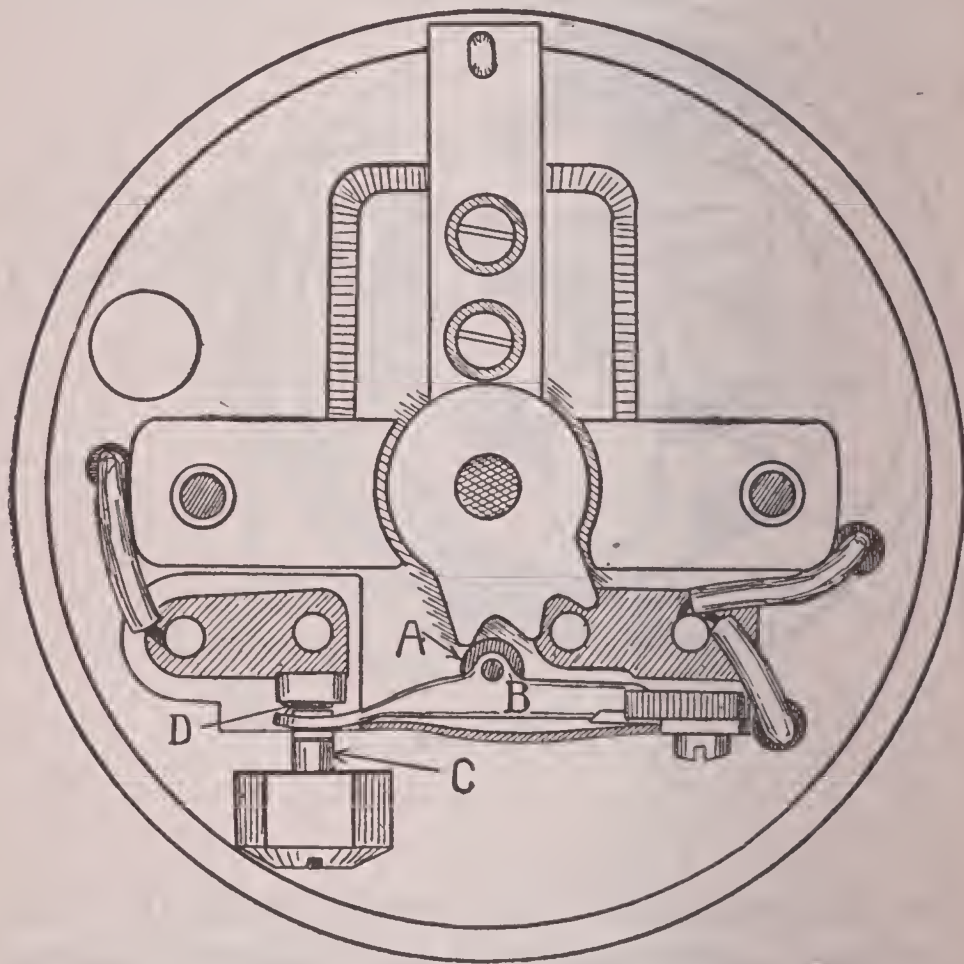


Fig. 197

Some of the coil units include a device, shown in Figure 197, for starting on the spark. The mechanism consists of a three tooth ratchet engaging a roller A on a lever B. This lever carries a double face contact. This contact makes and breaks the primary circuit by making contact alternately with the fixed points C and D. This action results in a stream of sparks at the spark plug in the cylinder then ready to fire and if there is a combustible mixture in the cylinder the engine will start.

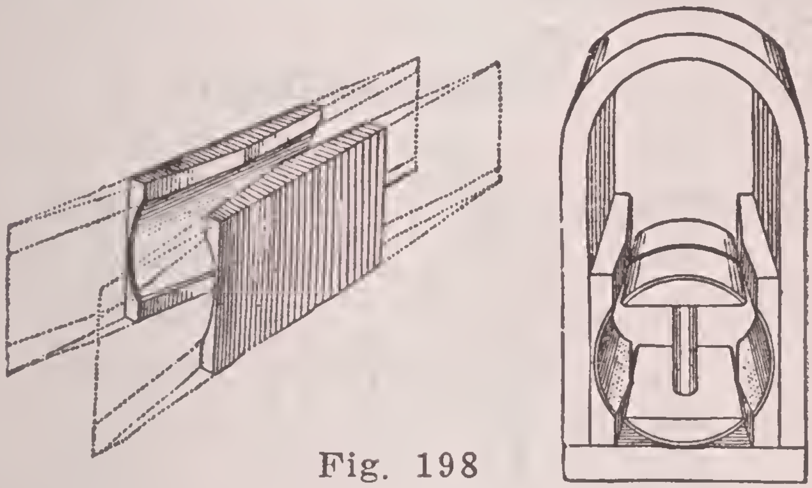


Fig. 198
Pole Piece Construction in Eisemann Magneto

The Eisemann dual system consists of a direct high-tension magneto and a combined transformer coil and switch. The transformer proper is used only in connection with the battery; the switch is used in common by both battery and magneto systems. The magneto is practically the same as the single ignition instrument. Separate windings and contact breakers are used for battery or magneto current. On the other hand, parts that are not subject to accident, or rapid wear, are used in common.

A distinctive feature is that the pole pieces are of a certain shape, Fig. 198, whereby the most extended portion thereof is approximately opposite the theoretical axis of the winding upon armature core. This construction results in the flow of the magnetic lines of force being drawn from the extremities of the pole pieces towards the center of the core; a large volume of the magnetic line of force is thus forced through the winding.

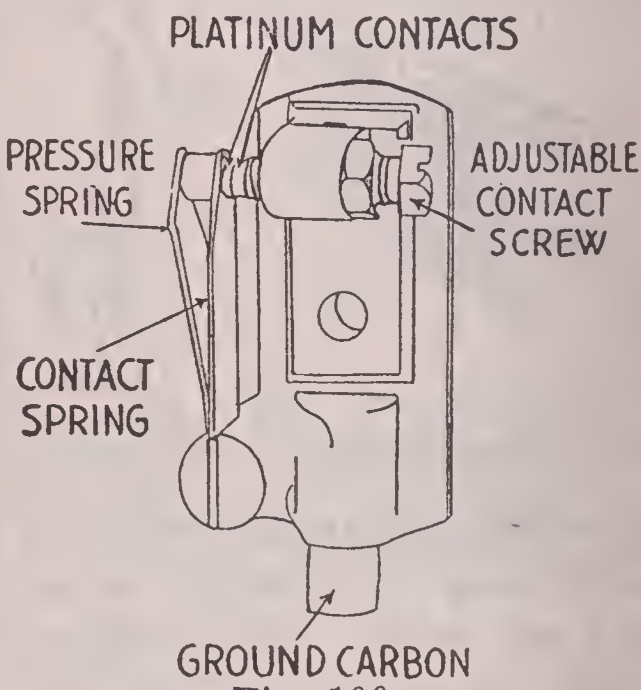


Fig. 199
Breaker of Eisemann Magneto

The make-and-break mechanism, Fig. 199, consists of a bronze plate on the back of which, and cast in one piece with it, is a cone, fitting into the armature shaft, which is bored out and provided with a key-way. It moves inside of the timing lever and is fastened to the armature by means of the screw. If this screw is extracted the whole mechanism can be removed.

The primary current is led from the winding through the armature shaft to the contact screw by the insulated screw, which also serves to hold the mechanism to the armature shaft as already described. When the armature reaches the correct position, a lever is lifted by two steel cams fastened to the magneto body; the primary circuit is broken and the current is induced in the secondary winding. The beginning of the secondary winding is connected with the end of the primary winding, and the other end, through several mediums, finally delivers the spark in the cylinder.

In addition to this the magneto is also fitted with the battery circuit breaker, which is mounted at the back of the magneto breaker. It consists of a steel cam, having two projections which actuate a steel lever mounted into the breaker housing.

A condenser is built in between the T-shaped end of the armature and the bearing. This prevents a spark occurring at the platinum contacts with the consequent pitting and burning, when the contact breaker opens, and it also increases the intensity of the spark at the plugs.

The coil consists of a non-vibrating transformer and a switch, which is used in common to put either the battery or magneto ignition into operation. It is cylindrical in shape, compact, and is placed through the dashboard. The end which projects through on the same side as the motor has terminal connections for the cables. The other end, facing the operator, contains the switch and the starting mechanism. The transformer proper is used only in conjunction with the battery.

As the spark occurs when the primary circuit is broken by the opening of the platinum contacts, it is necessary that the magneto will be so timed that at full retard the platinum contacts will open when the piston has reached its highest point on the firing stroke. To arrive at this, turn motor by hand until piston of No. 1 cylinder is on the dead center (firing point). Place the timing lever of the magneto in fully retarded position, then turn armature of magneto until No. 1 appears at the glass dial of the distributer plate, and make sure that the platinum contacts of the magneto are just opening. Fix the driving medium in this position.

If no window is seen, turn motor by hand until piston of No. 1 cylinder is on dead center (firing point), remove the distributer plate from the magneto and turn the drive shaft of the armature until the setting mark on the distributer disc is in line with the setting screw above the distributer. (For magneto rotating clockwise use setting mark R, and for counter clockwise use mark L.) With the armature in this position the platinum contacts are just opening and the metal segment of the distributer disc is in connection with carbon brush for No. 1 cylinder. The driving medium must now be fixed to the armature axle without disturbing the position of the latter, and the cables connected to the spark plugs.

If a spark plug cable becomes disconnected or broken, or should the gap in the spark plug be too great, then the secondary current has no path open to it, and endeavoring to find a ground will sometimes puncture the insulation of the armature of the coil. To obviate this, a so-called safety spark gap is placed on the top of the armature dust cover. It consists of projections of brass with a gap between them. One of these is an integral part of the dust cover, and therefore forms a ground. The other brass part is connected with the terminal H M and the secondary current will jump across the intervening gap above mentioned, thus protecting the armature secondary winding and the high tension insulations.

In the coil, this safety gap is placed at one end of the core, and hence is not visible. It consists of a pointed brass finger, attached to one end of the secondary, and pointing towards the iron core of the coil.

The contact points may be cleaned with gasoline until the contact surface appears quite white, or use a fine file, but very carefully, so that the surfaces remain square to each other. The gap at the contact points should not amount to more than 1/64 inch and, as the contacts wear away in time, they must be regulated now and then by giving the screw a forward turn, or eventually by renewing. When this platinum tipped screw is adjusted, care must be taken that the lock-nut is securely tightened in place. By loosening the center screw, the whole interrupting mechanism may be taken out, so that the replacement of the platinum contacts without removing the apparatus can be easily done at any time. The fixing screw of the make-and-break is held fast by a lock spring, so that it is impossible for this screw to loosen. When it is desired to remove this screw, the lock spring must first be removed by turning it over the head of the screw. Do not forget to put the spring in the original position after having fixed the make-and-break to the armature.

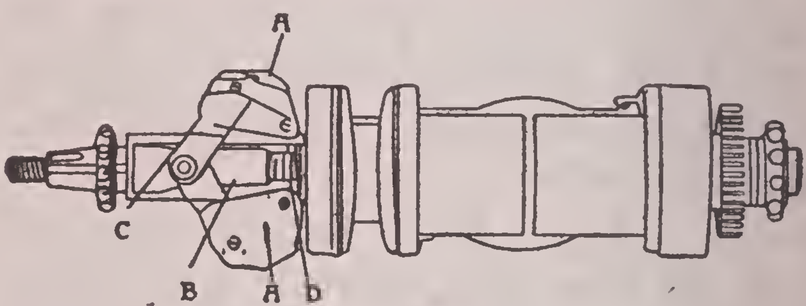


Fig. 200
Automatic Advance Mechanism of Eisemann Magneto

The Eisemann automatic advance, Fig. 200, is accomplished by the action of centrifugal force on a pair of weights A attached at one end to a sleeve B, through which runs the shaft C of the magneto, and hinged at the other end to the armature.

Along the armature shaft arm run two spiral ridges which engage with similarly shaped splines in the sleeve. When the armature is rotated the weights begin to spread and exert a longitudinal pull on the sleeve which in turning changes the position of the armature with reference to the pole pieces. In this way the moment of greatest current is advanced or retarded, and with it the break in the primary circuit, for the segments which lift the circuit breaker and cause the break in the primary circuit are fixed in the correct position and thus the break can only occur at the moment when the current in the winding is strongest. On magnetos without this advance it is the segments which are moved forward or back, as the case may be. As there is only one actually correct position for the segments, every degree away from this weakens the spark.

The spreading of the weights rotates the armature forward, and advances the spark and the resumption, either total or in part, of their original position close to the shaft, retards it by rotating the armature backward.

As the timing is accomplished by changing the relative positions of armature and motor and not those of the segments in the timing level which cause the breaking of the circuit, the spark is always bound to occur at the moment of greatest current and the apparatus thus given as strong a spark at retard as when fully advanced.

As the speed becomes slower a spring D brings the weights together again, so that by the time the motor has come to rest the magneto is fully retarded.

In the rear end of the governor housing there is a transverse slot into which fits a key, fur-

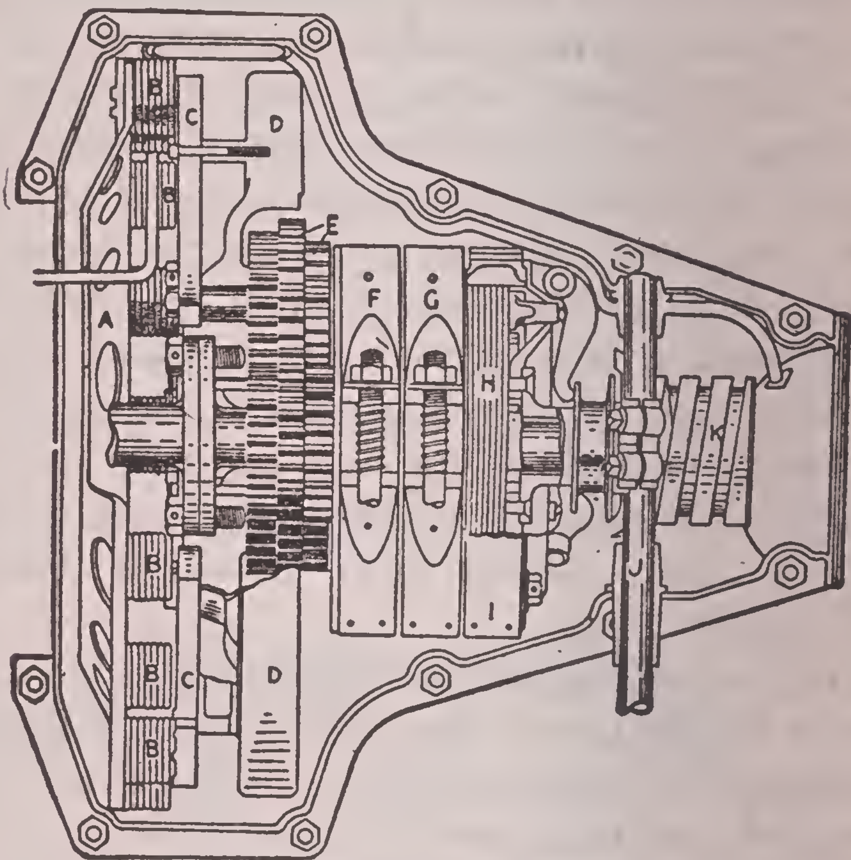


Fig. 201
Magneto Used on the Ford Cars

nished with each magneto. When this key is shoved in as far as it can go the armature is fixed in the position where the platinum contacts begin to open. The coupling may be screwed up with the assurance that the magneto is correctly set and without danger of damaging the armature.

Ford Magneto. The Ford magneto, Fig. 201, is of a peculiar design, it being constructed as an integral part of the flywheel, in which A is the support for the magneto coils; BBB, magneto coils; CC, permanent horseshoe magnets; DD, the flywheel; E, planetary pinions; F, low speed brake band; G, reverse brake band; H, disc-clutch for high speed; I, transmission

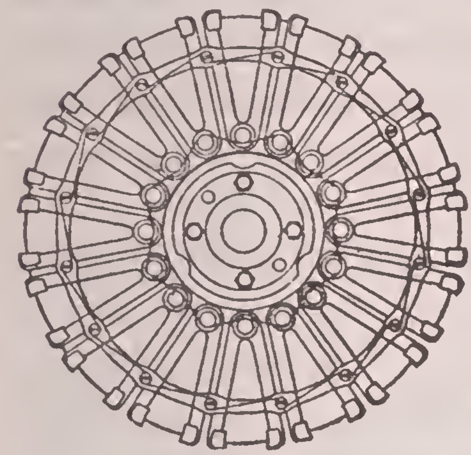


Fig. 202

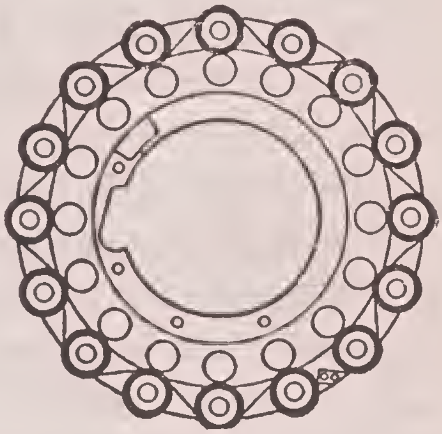


Fig. 203

Details of Ford Magneto

brake; J, clutch rocker shaft, and K, high speed clutch spring. The permanent magnets, which are U-shaped, are bolted to the forward face of the flywheel, as shown in Fig. 202. Close in front of their outer ends is a series of insulated coils mounted in a circle of practically full flywheel diameter, with their axes parallel with that of the crankshaft. They are supported upon a stationary spider, as shown in Fig. 203. As the flywheel revolves, this magnet and coil combination, which is similar to that used on some types of alternating current generators, produces a current which is used through a four-unit current timer to cause the ignition spark. The magneto is of the inductor type, the armature coils being stationary, and the field magnets moved past them. Sixteen separate field magnets are used, made of vanadium-tungsten steel. They are substantially horseshoe shape, being secured to the side of the flywheel as illustrated in Fig. 203. They are held in place by screws at their middle, and by clamps near their poles, all screws used for fastening them being securely locked in place by wire locks.

The magnets are so arranged that like poles are adjacent to each other, forming a sixteen pole field magnet crown. Instead of being placed close against the flywheel, these magnets are clamped against a ring of non-magnetic material (brass for instance), in order to reduce leakage of magnetism through the flywheel rim. At their middle these magnets are fastened directly to the flywheel, as at this point they are neutral, and there can be no leakage. A series of sixteen armature coils is carried on a coil supporting ring slightly in front of the flywheel, as shown in Fig. 202. These coils are wound with heavily insulated magnet wire, and are so grouped around the supporting ring that the winding of adjacent coils is in different directions, one being wound clockwise, and the next one counter clockwise. The coils are connected in series, the terminals being brought out near the top of the casing. As the poles of the magnets are located opposite and very close to the coils, the magnetic circuits are completed by the cores of these coils and the coil support. There are evidently sixteen electrical impulses produced during the revolution of the crankshaft and flywheel, although only two impulses are required for the ignition of the motor, one per stroke. However, as the armature circuit is closed only when a spark is wanted, a current only flows at that period, and there is no loss from the other impulses.

Mea Magneto. The most noticeable difference between the Mea magneto and other standard forms is that the magnets are bell-shaped and are placed horizontally and with their axes in line with the armature shaft. This is a distinct variation from the customary horseshoe magnets placed at right angles. This makes possible the simultaneous movement of the magnets and breaker instead of the advance and retard of the breaker alone.

It will be seen that, as a result of this construction, the relative position of armature and field at the moment of sparking is absolutely maintained, and the same quality of spark is therefore produced, no matter what the timing may be.

Fig. 204 shows a longitudinal section of a four-cylinder instrument. In the bell-shaped magnet 100, having the poles on a horizontal line near the driven end of the magneto, rotates armature 1 in ball bearings 17 and 18. The armature consists mainly of an I-shaped iron core, mounted on a spindle, and wound with a heavy primary winding of a few turns and a light secondary winding of many turns. On this armature are also mounted the condenser 12, the collector ring 4, and the low-tension

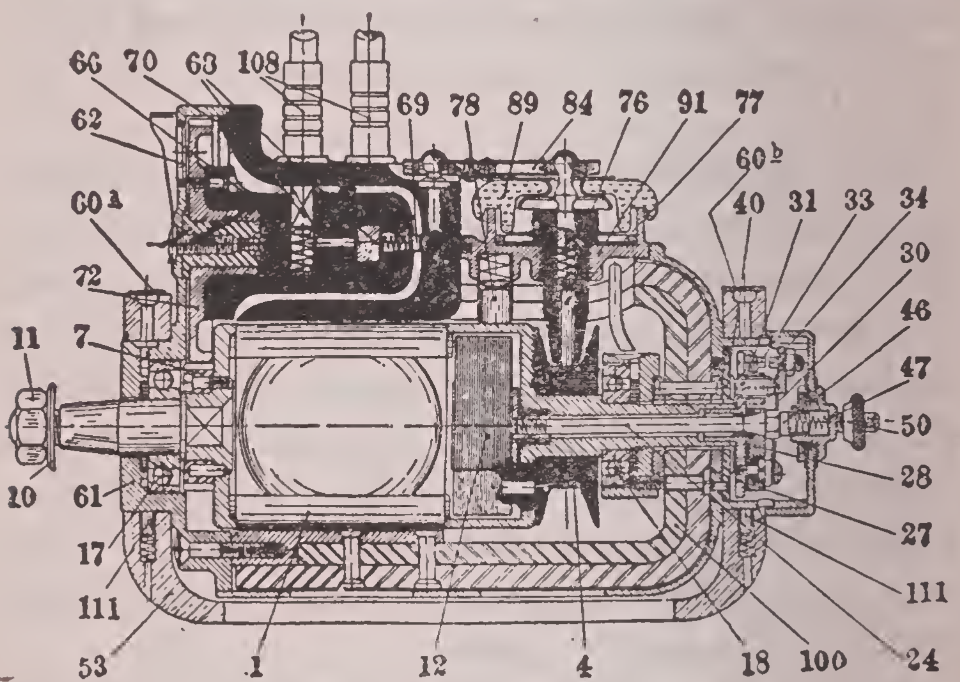


Fig. 204
Mea Magneto

breaker 26-39. The latter is built up of a disc 27, which carries the short platinum contact 33; the other contact point 34 is adjustable and supported by a spring 20, which in turn is fastened to the insulated plate 28 mounted on disc 27. The breaker is actuated by the fibre roller

31 in connection with cam disc 40, which is provided with two cams and located inside the breaker, being fastened to the field structure. In revolving with the armature the roller presses against the spring supported part of the breaker whenever it rolls over the two cams and in this manner opens the breaker twice every revolution. Inspection of the breaker points is made possible by means of an opening in the side of the breaker box, provided at the point of the circumference at which the breaker opens. The box is closed by a cover 74, supporting at its center the carbon holder 47, by means of which the carbon 46 is pressed against screw 24. This latter screw connects with one end of the low tension winding, while the other end is connected to the core of the armature. It will, therefore, be seen that the breaker ordinarily short-circuits the low tension winding and that this short-circuit is broken only when the breaker opens; it will also be apparent that when the screw 24 is grounded through terminal 50 and the low-tension switch to which it is connected, the low-tension winding remains permanently short-circuited, so that the magneto will not spark. The entire breaker can be removed by loosening screw 24.

The high tension current is collected from collector ring 4 by means of brush 77 and brush holder 76, which are supported by a removable cover 91, which also supports the low tension grounding brush 78 provided to relieve the ball bearing of all current which might be injurious. Cover 91 also carries the safety cap 89, which protects the armature from excessive voltages in case the magneto becomes disconnected from the spark plugs.

The distributer consists of the stationary part 70 and the rotating part 66, which is driven from the armature shaft through steel and bronze gears 7 and 72. The current reaches this distributer from carbon 77 through bridge 84 and carbon 69. It is conducted to brushes 68 placed at right angles to each other and making contact alternately with four contact plates embedded in part 70. These plates are connected to contact holes in the top of the distributer, into which the terminals of cables leading to the different cylinders are placed.

In the front plate of the magneto is provided a small window, behind which appear numbers engraved on the distributer gear which correspond to the numbers marked on the top of the distributer. This indicator allows a setting or resetting after taking out, without the necessity of opening up the magneto to find out where the distributer makes contact. Numbers on indicator and distributer show the sequence of sparks, not the numbers of cylinders which the magneto is firing, as the sequence of firing varies with different motors.

The variation of timing is effected by turning the magneto proper in the stationary base which is accomplished through the spark lever connections attached to one of the side lugs. The spark is advanced by turning the magneto in the direction of the rotation of the armature.

If the magneto is defective, the trouble will usually be located in the breaker. The platinum contacts burn off in time and a readjustment becomes necessary, although this should be the case only at very long intervals. The adjustment should be such that the breaker begins to open with the armature in the position of greatest current flow, and that the distance between contact points when fully open is about 1/64 inch or slightly more. The small gauge attached to the magneto wrench may be used for checking this adjustment. The small lock nut of the contact screw must be tightened securely after each readjustment of the contacts.

In addition any oil or dirt reaching the contact points will in time form a fine film which prevents perfect short-circuit of the low-tension winding. If the condition of these points is very bad, or if a complete inspection of the breaker is desired, the latter should be removed from the breaker box. This can readily be done by loosening the long center screw holding the breaker to the armature, and screwing it into the small tapped hole provided in the breaker, so that it may be used as a handle in lifting the breaker out. The cleaning of the points should be done with a fine crocus paper, or if necessary, with a very fine file, after which a piece of very fine cloth should be passed through between the points so as to remove all sand or filings. Special care must be taken not to round off the edges of the contact points; the satisfactory operation of a magneto depends largely upon the perfect contact at this point, and the whole surface of the contacts should therefore touch.

REMY MAGNETOS. The first models of Remy magnetos were constructed on the inductor principle which may be understood by reference to Figure 205. The magnets M are of the horseshoe type and have their positive and negative poles on opposite sides of the rotating inductor A which is made of laminated iron and carried on the driving shaft S. The inductor consists of a central portion having extensions at each end, the extension at one end pointing one way while the other extension points in the opposite direction. Around the center of the inductor is wound a stationary primary coil C.

With the parts as shown in position 1 the flow of magnetism from the positive to the negative magnet pole passes downward through the coil. At the end of a quarter turn, position 2, the extensions of the inductor are midway between the magnet poles and the flow of magnetism is ready to reverse its direction. In position 3 the flow has reversed and a powerful current impulse has been induced in the coil winding. Continued rotation of the shaft causes a succession of impulses in the coil and these current waves are used, as in the revolving armature magneto, for the production of a secondary current in a separate coil.

The breaker mechanism used with one of the Remy inductor models is shown in Figure 206. The contact gap of this instrument may be adjusted from outside of the housing.

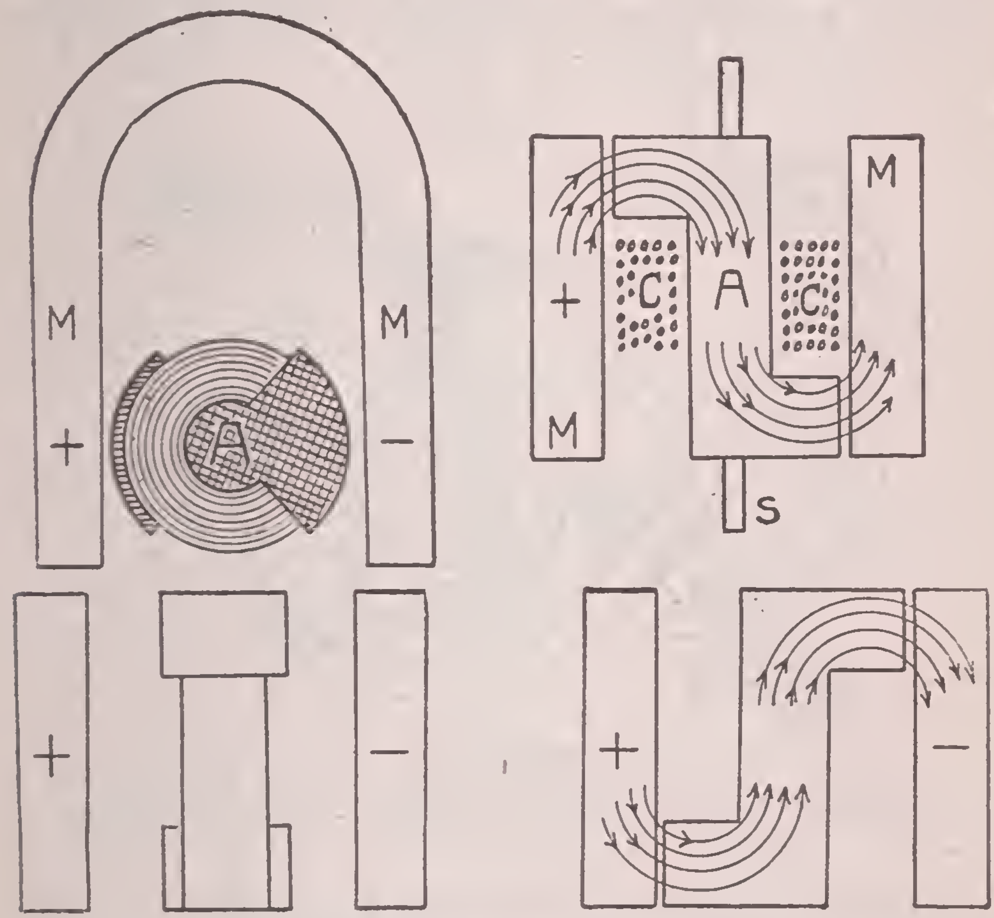


Fig. 205

The inductor principle is not used in later models of the Remy magneto, this feature being replaced by an armature of the shuttle type with a single low-tension winding. A separately mounted transformer coil is used with these instruments, this coil carrying a switch that allows use of the current from the magneto armature or from a set of dry cells or storage battery, the current, from whichever source, passing though the same breaker, coil, distributor and plugs.

The breaker of the new models is composed of a steel cam mounted upon and turning with the armature shaft and which strikes against a contact piece in a pivoted arm that carries one of the contacts of the breaker. Except for the

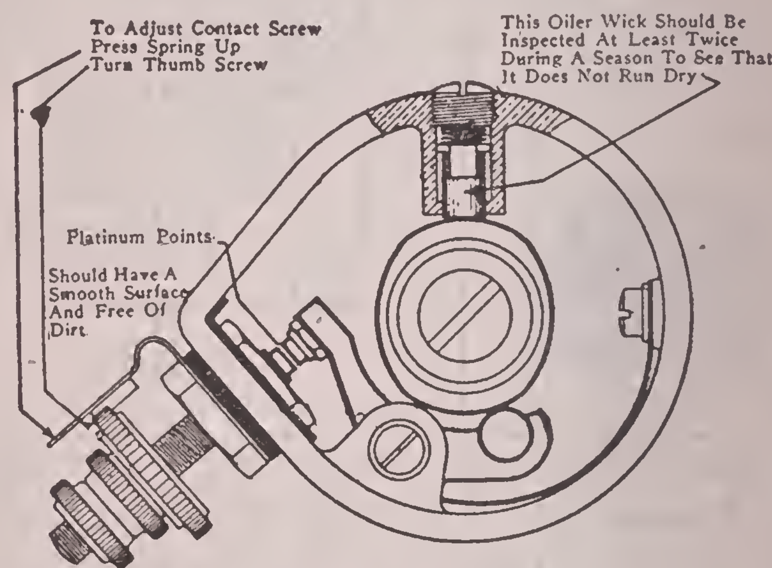


Fig. 206
Breaker Mechanism of Remy "RD" Magneto

movement required in altering the time of the spark, the contacts and the pivoted arm remain stationary, the cam being the only revolving part of the breaker mechanism. The condenser that is attached between the breaker contacts is carried in a housing that is mounted above the magneto armature and between the magnet legs.

A device, known as a timing button, is incorporated on the Models "P," "30," "31" and

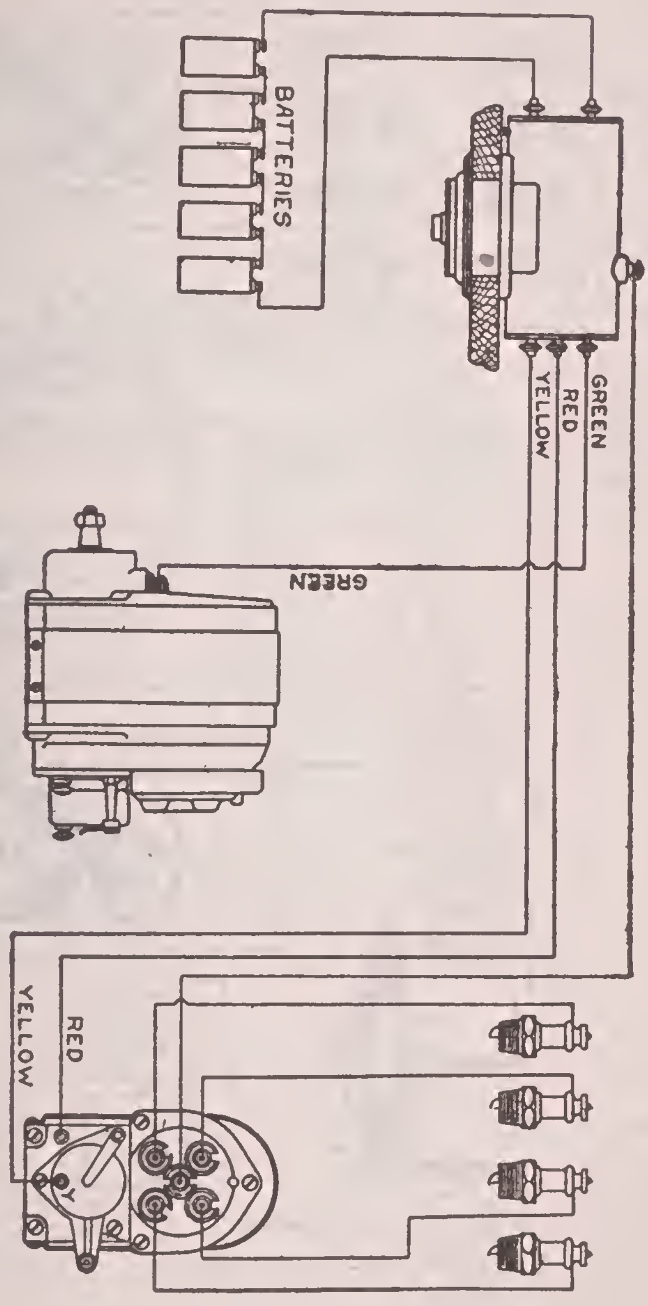


Fig. 207

Wiring of Remy Magnetos "P" and "32"

"32" Remy magnetos, for the purpose of timing the magneto in connection with the engine.

To set the magneto turn the engine crankshaft until the piston of No. 1 cylinder is at top cen-

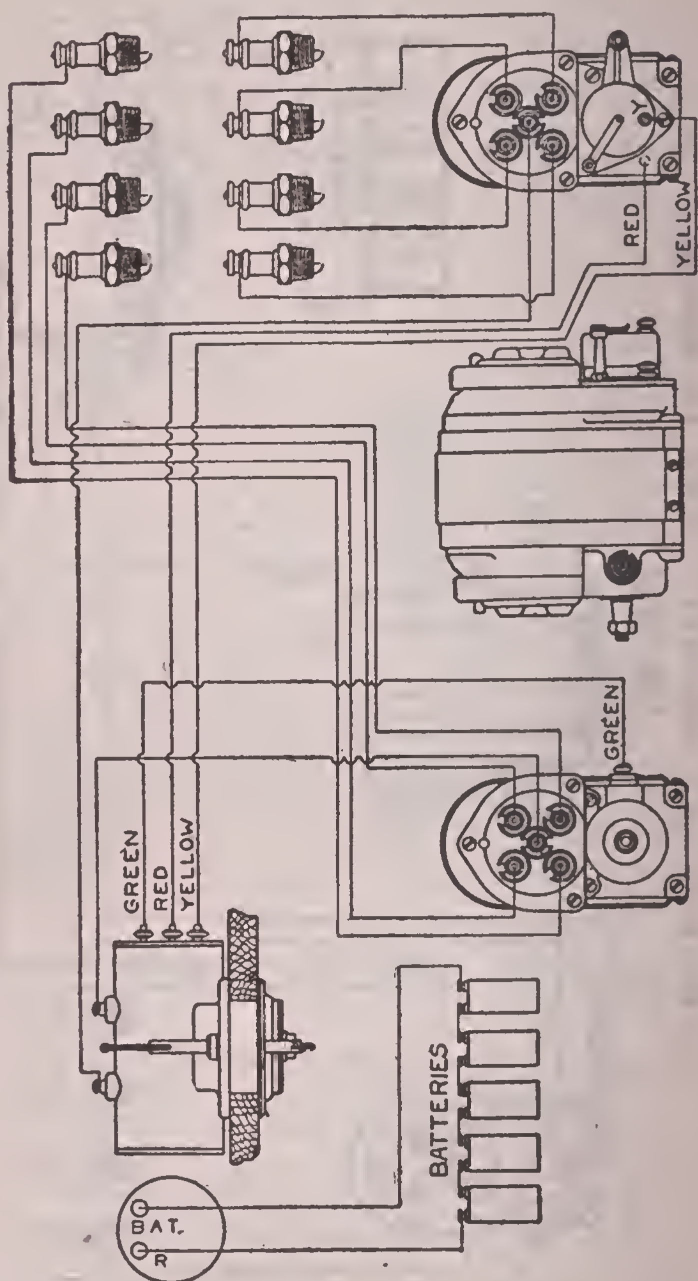


Fig. 208
Wiring of Remy Magnetos "30" and "31"

ter after the compression stroke. Press in on the timing button at the top of the distributor and turn the magneto shaft until the timing button is felt to drop into the recess on the distributer gear. With the magneto in this position, make the coupling with the engine without paying any attention to the position of the breaker cam. The location of the distributer terminal for the plug in No. 1 cylinder is determined by the direction of rotation of the magneto. If the magneto runs clockwise, No. 1 terminal is at the lower left hand corner of the distributer, while for anti-clockwise drive No. 1 terminal is at the lower right hand corner. The wiring for the Models "P" and "32" is shown in Fig. 207, while the connections for Models "30" and "31" are shown in Fig. 208.

Simms Magneto. The armature is of the true high-tension type, on which is wound both the low-tension primary and high-tension secondary windings, connected in series. The magneto generates a high-tension current directly in the armature, and does not use an exterior coil or other device to step-up or transform the current.

A safety spark gap is provided to prevent damage to the magneto, in the event of one or more of the high-tension cables becoming disconnected from the spark plugs. This gap is so located that its action may be readily observed for the purpose of locating the cause of possible misfiring.

The model "S U D" consists of a dual system in which is provided a small non-vibrating coil which can be either attached to the frame or dash of car, as the coil is unaffected by either moisture or heat.

The switch operating the battery circuit is in connection with the starting switch and when the starting pedal is depressed (thereby throwing the starting motor into operation) the current flows through the switch coil and magneto.

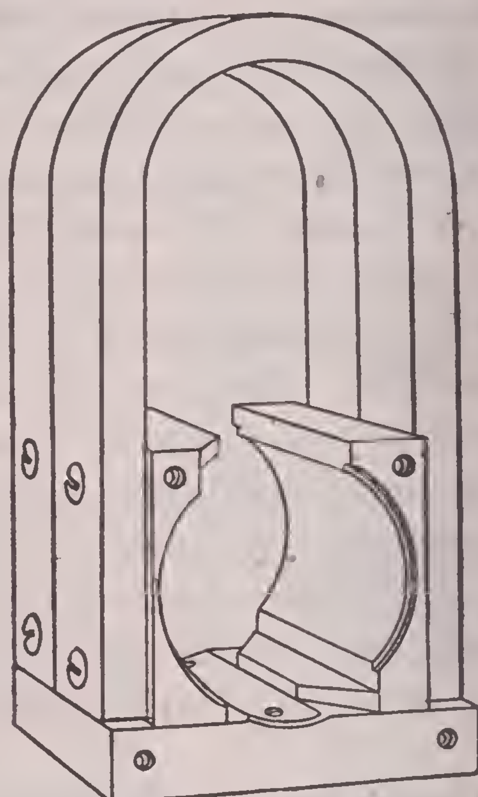


Fig. 209
Magnets and Extended Pole Pieces of Simms Magneto

As soon as the engine starts, or the starting pedal is released, the circuit is automatically disconnected, and the engine runs on the magneto. One of the principal features of the Simms magneto is the extended pole shoe, shown in Fig. 209.

To time the magneto to engine: Turn the engine over by the starting crank until No. 1 piston reaches top dead center on compression or firing stroke. Remove the dust cover, or if a dual magneto, the commutator, and turn the armature shaft until the figure 1 appears in the "sight-hole" of distributor, Fig. 210. This shows that that distributor brush is in contact

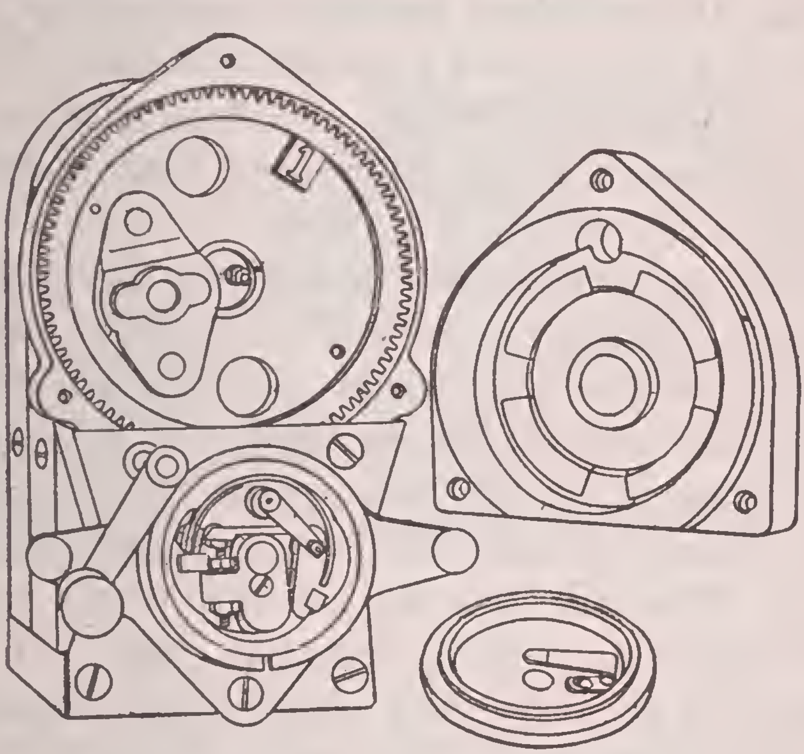


Fig. 210
Simms High Tension Magneto

with distributor post 1. Retard the contact breaker and move the armature, either to the right or left, as occasion requires, until the platinum points just break, or, in other words, just separate. With the magneto in this position couple it to the engine (to dead center on compression stroke), and connect the remaining terminals up in the proper firing order of the engine.

For timing the model S U D, proceed as above. The above instructions relative to engine position apply also in this instance. The only change is as follows:

For locating the position of the carbon brush on No. 1 distributer segment, remove the distributer, which is held in place by means of two spring clips, and turn the armature shaft until the distributer brush is brought into position, namely, opposite No. 1 segment.

If the magneto is not firing, try the following test. While the motor is running, disconnect one of the high tension cables from spark plug, being careful not to touch the metal terminal, and hold the cable with the terminal close, about 1/8″ to 3/16″, to any part of the motor. This will show the strength of the spark and each cable may be tested in turn. If the magneto is not delivering a good spark, examine the contact breaker. The break or gap between the platinum points, when open due to the cam action, should correspond to the thickness of the gauge furnished, which is approximately .015.

Splitdorf Magneto. The system used in older models is that having an armature with but one winding, and giving a current of comparatively low tension. The current is discharged through a transformer having a low and a high-tension winding somewhat similar to regular spark coil. This steps the current up to a voltage sufficiently high to enable it to jump the necessary gap between the points of a spark plug in the compressed mixture in the cylinder of the motor.

The plain H, or shuttle, armature is mounted between two annular ball bearings, Fig. 211. One end of the shaft is the driving end and the other is equipped with the breaker cam and the

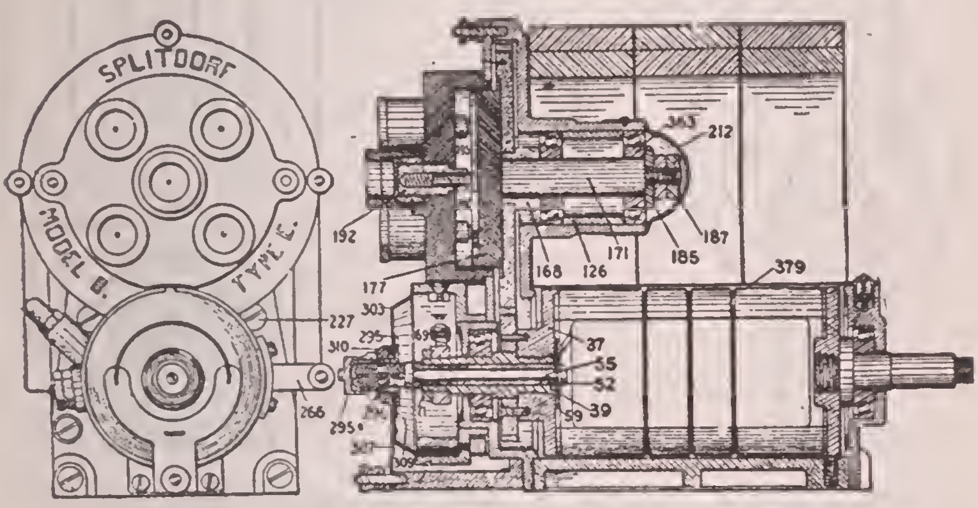


Fig. 211
Section Through Splitdorf Magneto

insulation plug which delivers the current generated in the armature to the collector brushes from which it is transmitted to the transformer connection.

From A, Fig. 212, the armature current goes through the primary of the transformer, returning through the binding post No. 2 to the contact screw bracket on the breaker box. No. 3 is a common ground connection for both the magneto and transformer. The circuit being broken at the proper moment, a very high voltage current is induced in the secondary winding of the transformer, and being delivered to the heavily insulated cable D, is conducted to the central brush of the distributor, whence it is delivered to the spark plugs in the different cylinders in correct sequence.

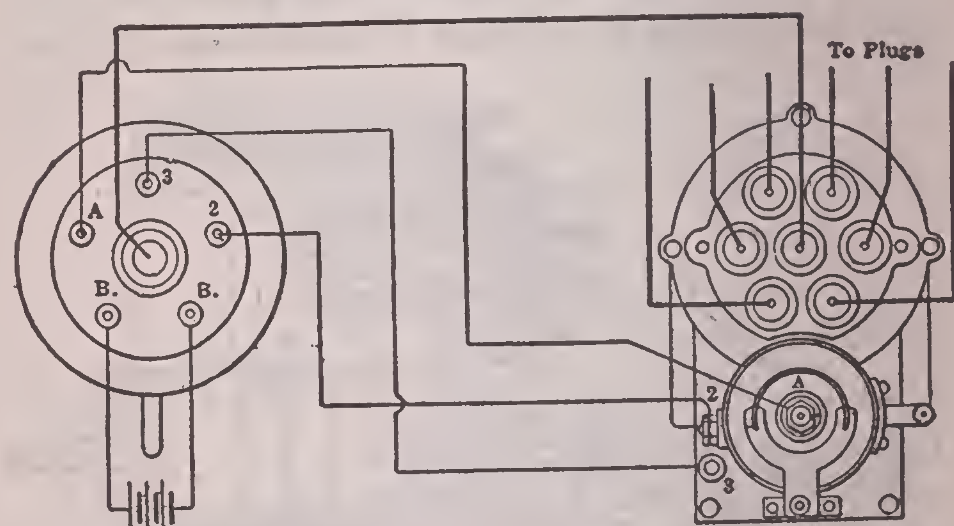


Fig. 212
Wiring of Model "S" Splitdorf Magneto

In addition to using the current from the magneto, the transformer may be used as a spark coil by using the breaker mechanism of the magneto in the circuit to interrupt a current from the battery, which can be switched in for starting purposes or for an emergency. The distributor is used to deliver the current thus generated to the spark plugs. This gives a dual system with one set of spark plugs, and the movement of the switch controls both systems. Fig. 213.

A later development is the new standard "T S" type of transformer, Fig. 214, which has practically superseded all other types, par-

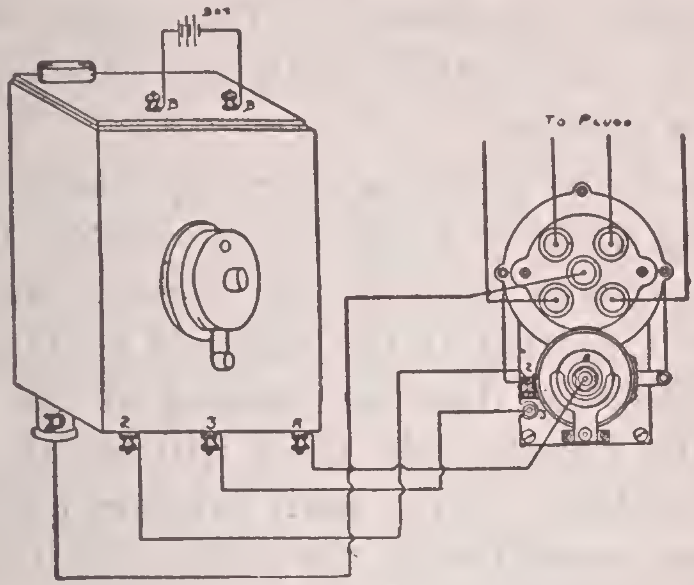


Fig. 213
Wiring of Splitdorf Magneto With Transformer Coil

ticularly as it does away with the separate switch and still leaves the dash free. Both leads from the battery must run direct to transformer.

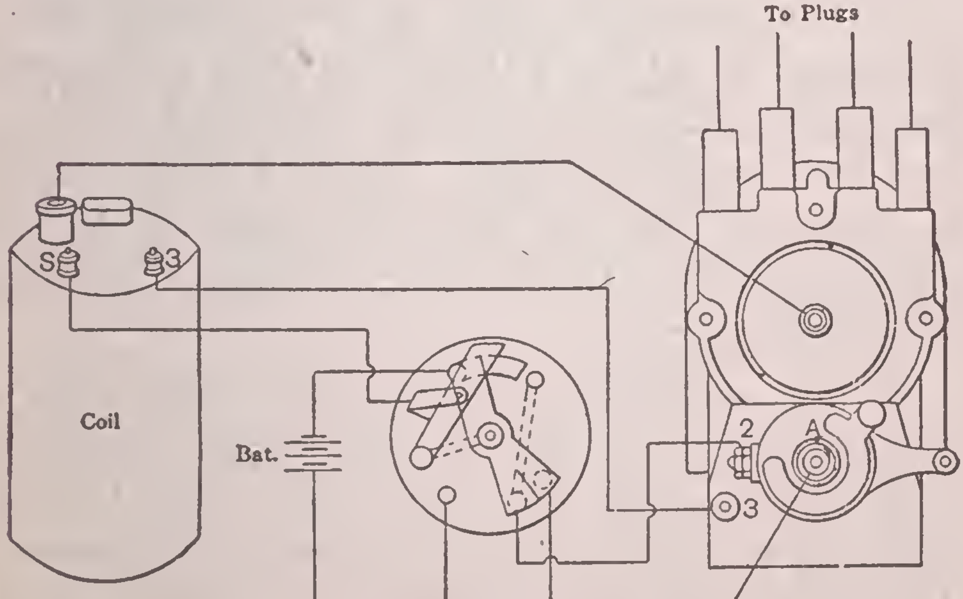


Fig. 214
Wiring of Splitdorf Magneto With Tubular Coil

After securing the magneto to the prepared base on the motor, crank it until cylinder No. 1 is exactly on its firing center (i. e., the point of greatest compression. The motor must remain in this position until the balance of the work is finished.

Retard the spark advance mechanism at the steering wheel to its limit and connect it to the spark advance lever on the breaker box of the magneto, so that if the magneto shaft revolves in a clockwise direction looking at the driving end, the breaker box lever will be at its topmost position. If the shaft revolves left-handed the lever should be at the bottom limit, and advanced upward.

Now revolve the armature shaft in its direction of rotation until the oval breaker cam comes in contact with the roller in the breaker bar and begins to separate the platinum contacts.

If it is desired to start on the magneto side, ignoring the battery entirely, advance the spark mechanism about one-half or two-thirds of the way and crank as before. No back kick should be observed. Do not drive the motor with the spark retarded, but as far advanced as the motor will permit.

If the platinum contacts after much usage become pitted so that a bad contact results, they can be filed flat with a fine file, taking care not to file off any more than is necessary. Then reset the screw so that the break is not more than .025 of an inch.

Don't forget to occasionally brush the distributer disc and interior of distributer block clean of any accumulation of carbon dust.

The "E U" magneto is a new high tension machine designed for four cylinder motors developing as high as 40 horse power.

The construction of this magneto embodies an aluminum base to which the pole pieces are secured, and between which revolves an armature on two annular ball bearings. The circuit breaker is attached to one end of the armature shaft and revolves with it. The magneto is self-contained, having both a primary and secondary winding on the armature.

The high tension winding of the armature is connected to a collector ring, imbedded in a spool mounted on the driving end of the armature shaft. From this ring a carbon brush leads the current through a water-proof holder to the center of the distributer disc.

The cam holder may be shifted to the extent of 30 degrees, enabling an advance or retard of the spark to be obtained, thereby causing ignition to take place earlier or later.

The condenser necessary for the protection of the platinum points and the proper functioning of the machine is placed in the driving head of the armature and revolves with it.

The distributer consists of a disc of insulating material having a metal segment to which the high tension current is led from the collector brush. The distributer block has four small carbon pencil brushes which lead the current to the brass connection imbedded in the block, to which the plug wires are fastened. The position of the segment on the disc can be seen through the little window in the face of the distributer block for the purpose of setting the machine when timing.

A spark gap for the protection of the armature winding is located at the inside end of the brush holder under the magnets.

The main bearings of the magneto are provided with oil cups, and a few drops of light oil every 1,000 miles are sufficient to lubricate them. The breaker arm should be lubricated with a drop of light oil applied with a toothpick to the hole in the bronze bearing pivoted on the steel pin. The cams are lubricated by a felt packing, and a little oil applied to the holes in the edge of the cams will last a long time; any surplus oil should be removed and care taken to prevent any oil getting on the platinum points.

The proper distance between the platinum points when separated should be .020 or 1/50 of an inch. A bronze gauge of the proper size is attached to the wrench furnished for the adjustment of the platinum screw and lock nut.

The fibre roller on the end of the breaker arm is held in position by a pawl spring. The wearing surface of the roller may be renewed by rotating the same a quarter turn, thus bringing a new surface to bear on the cam, and as there are four slots in the roller four wearing surfaces are available.

To time the magneto, rotate the crank shaft so as to bring the piston No. 1 cylinder 1/16 of an inch ahead of the upper dead center of the compression stroke. With the timing lever fully retarted, the platinum points of the circuit breaker should be about to separate. Some motors may require an earlier setting.

The distributor segment should show in the little window in the block and the plug wire to No. 1 cylinder should be fastened under the brass nut directly over the segment. The rest of the plug wires should be fastened in turn according to the proper sequence of firing of the cylinders to which they lead.

MAGNETO WIRING DIAGRAMS.

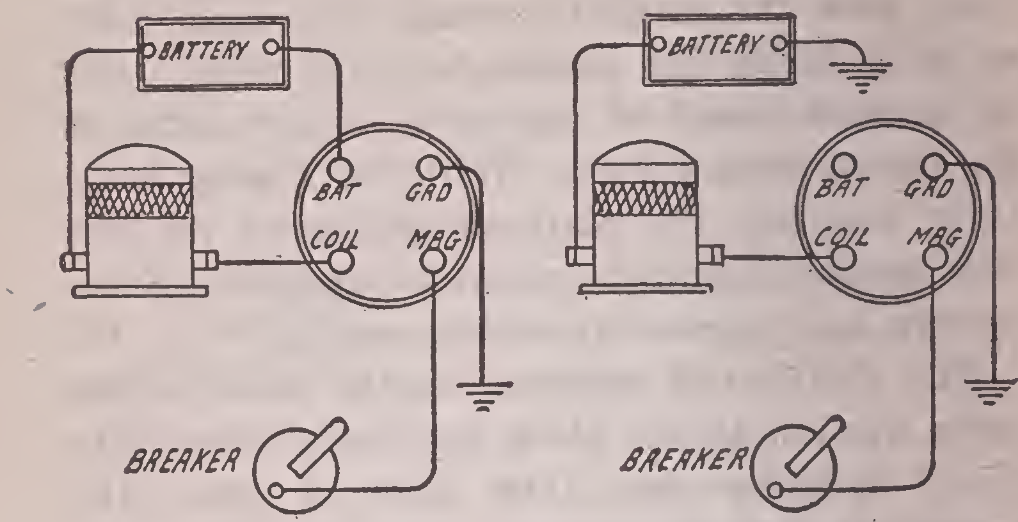


Fig. 215
Bosch Duplex Magneto Wiring for Grounded and Insulated Systems

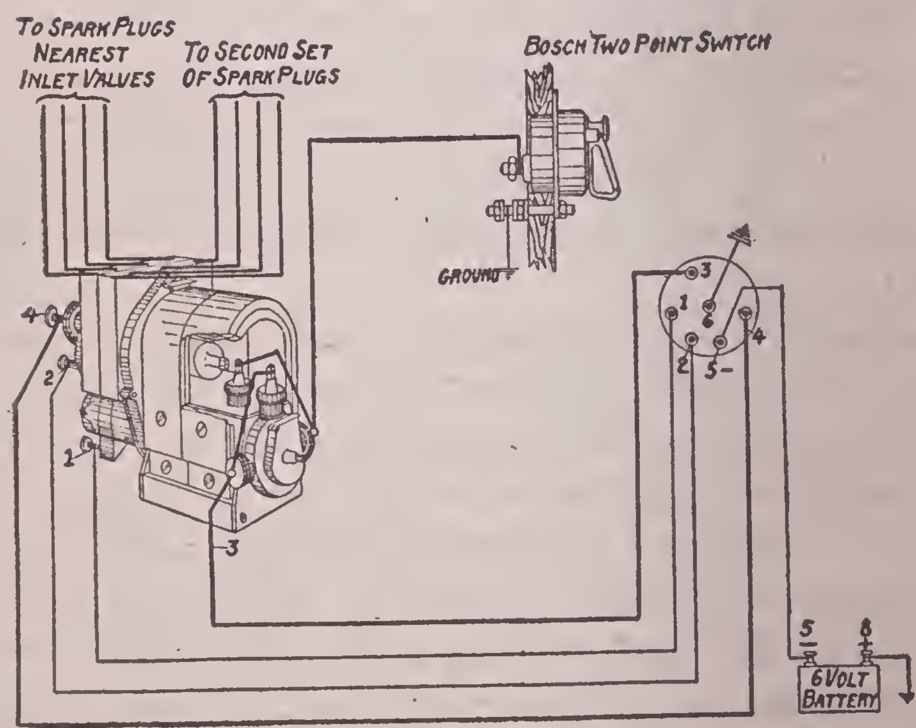


Fig. 216
Wiring of Bosch Two Spark Magneto, Models D and DR

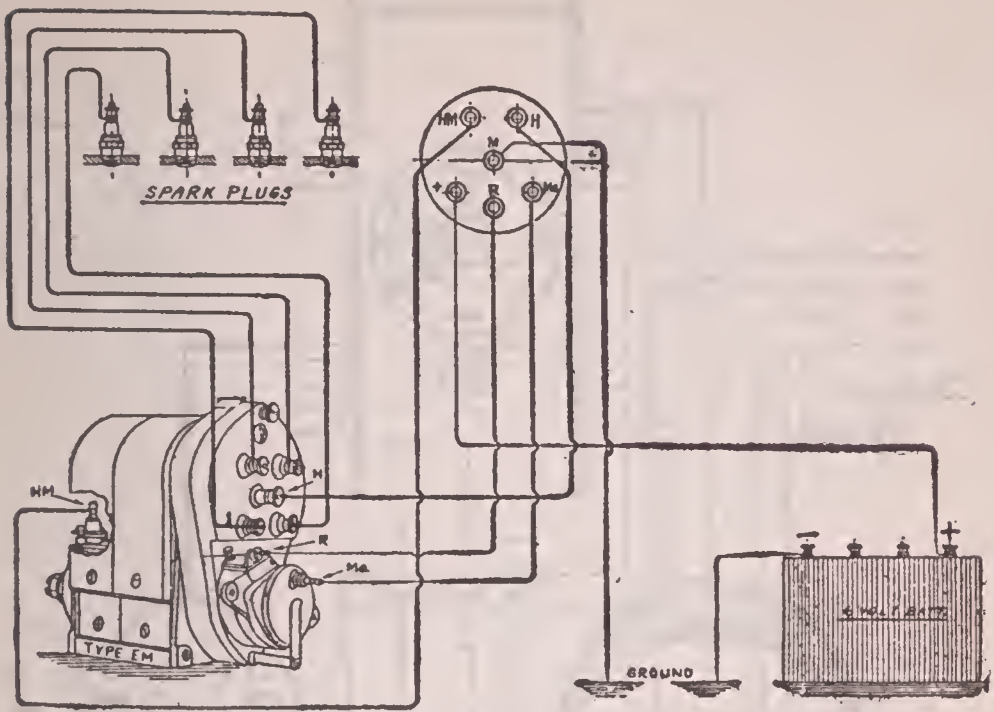


Fig. 217
Wiring for Eisemann Dual Magneto, Model EM 4

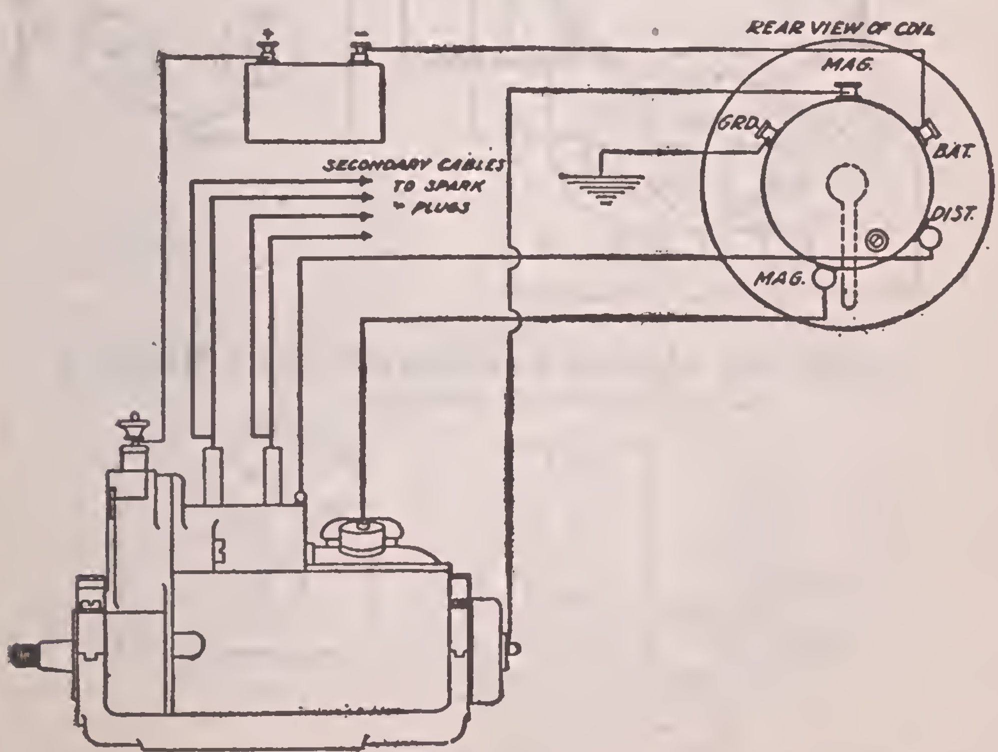


Fig. 218
Wiring of Mea Dual Magneto, Model SC

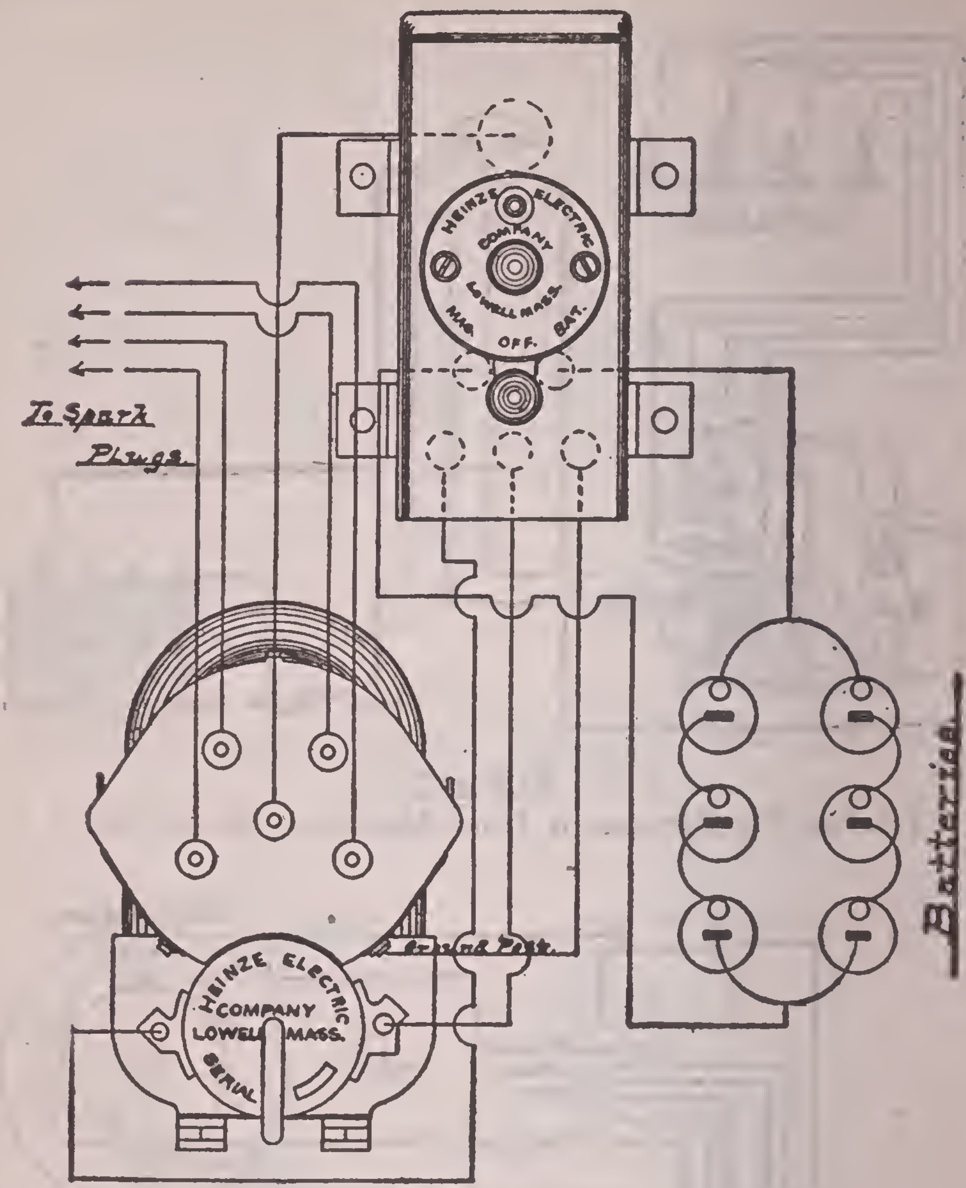


Fig. 219
Wiring for Heinze Transformer Coil Magneto

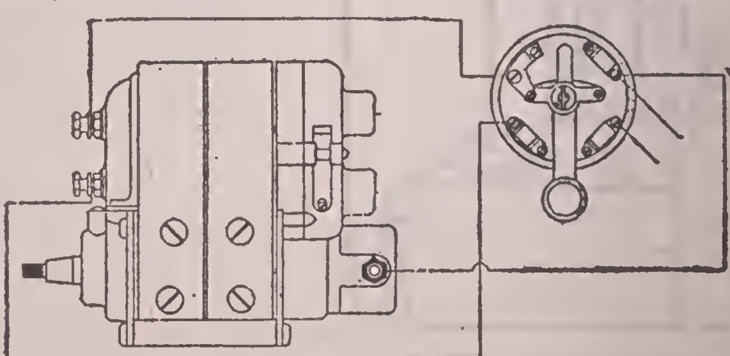


Fig. 220
Wiring for Kingston Transformer Coil Magnetos,
Models M and L

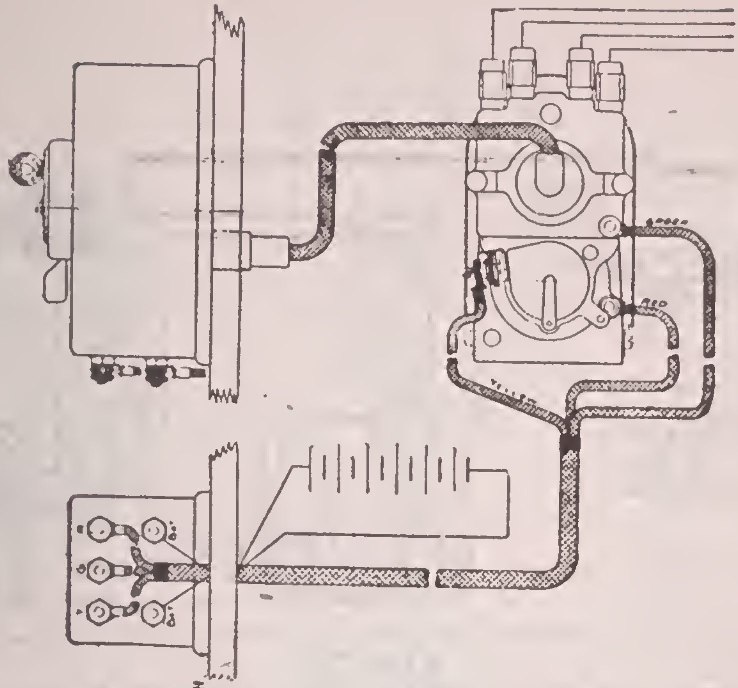


Fig. 221
Wiring for Remy R D Magneto

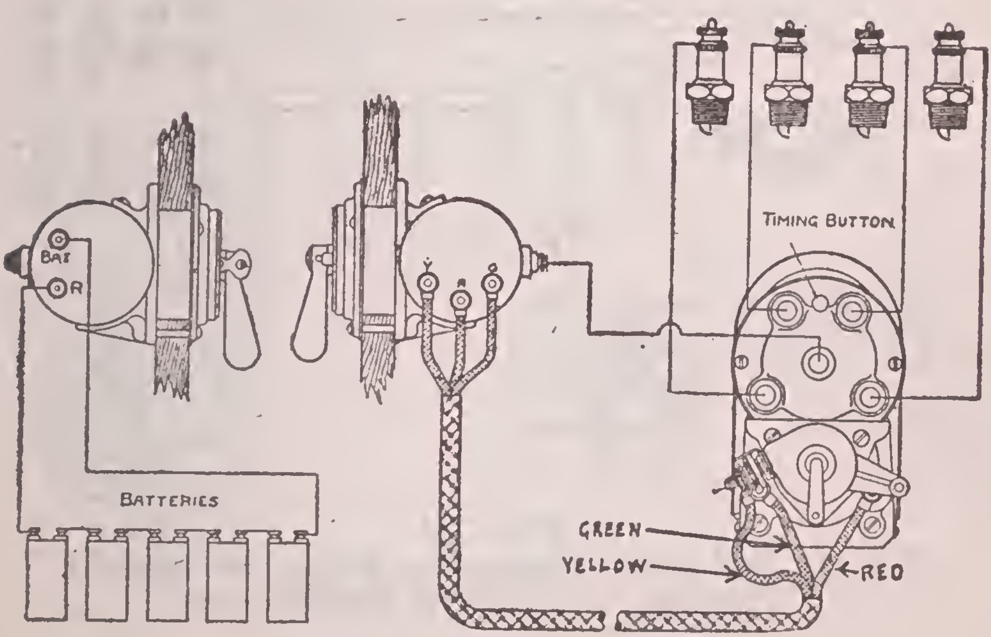


Fig. 222
Wiring for Remy R L Magneto

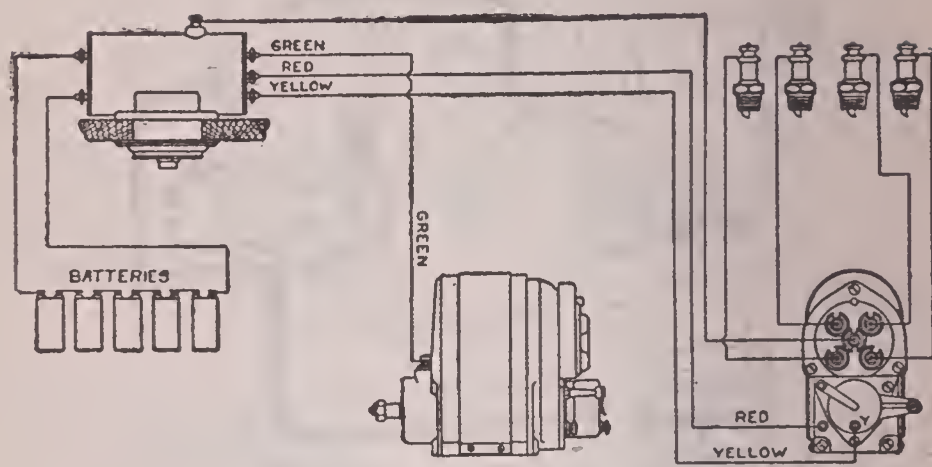


Fig. 223
Wiring for Remy Magnetos, Models P and 32

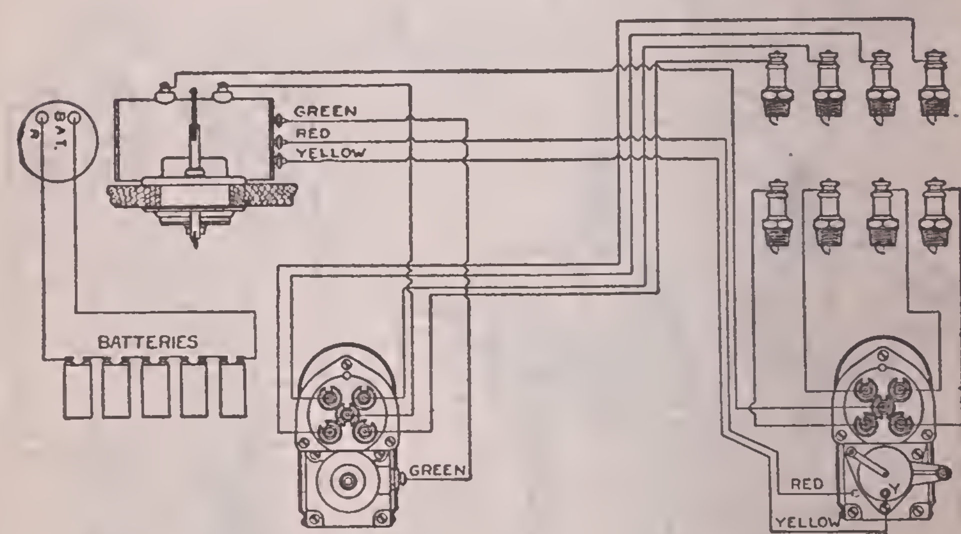


Fig. 224
Wiring for Remy Magnetos, Models 30 and 31
Showing Two Spark Distributor

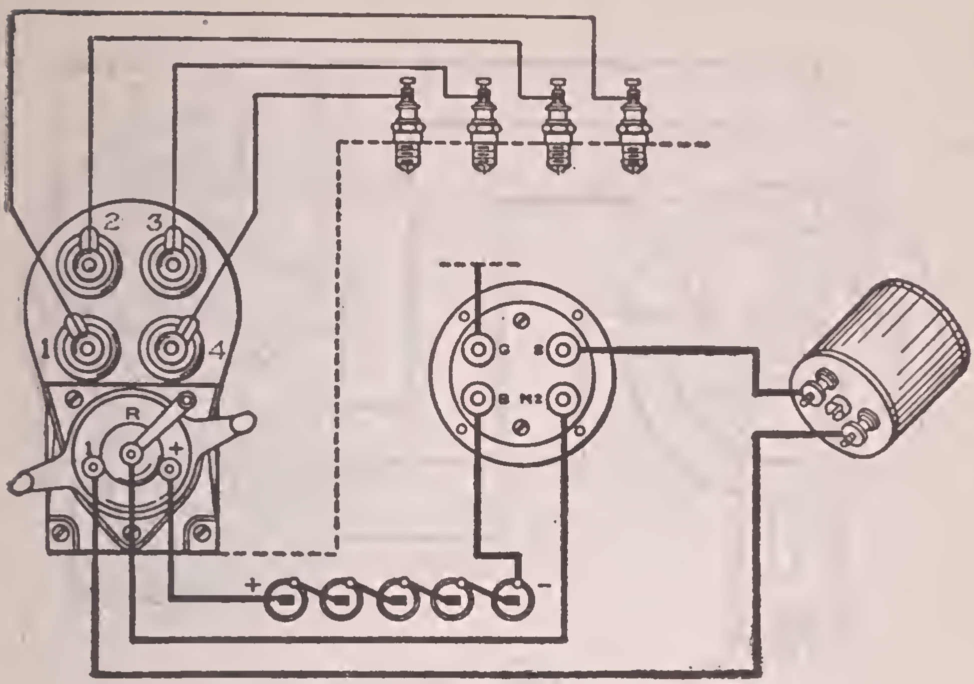


Fig. 225
Wiring for Simms Magneto Model SU4-D

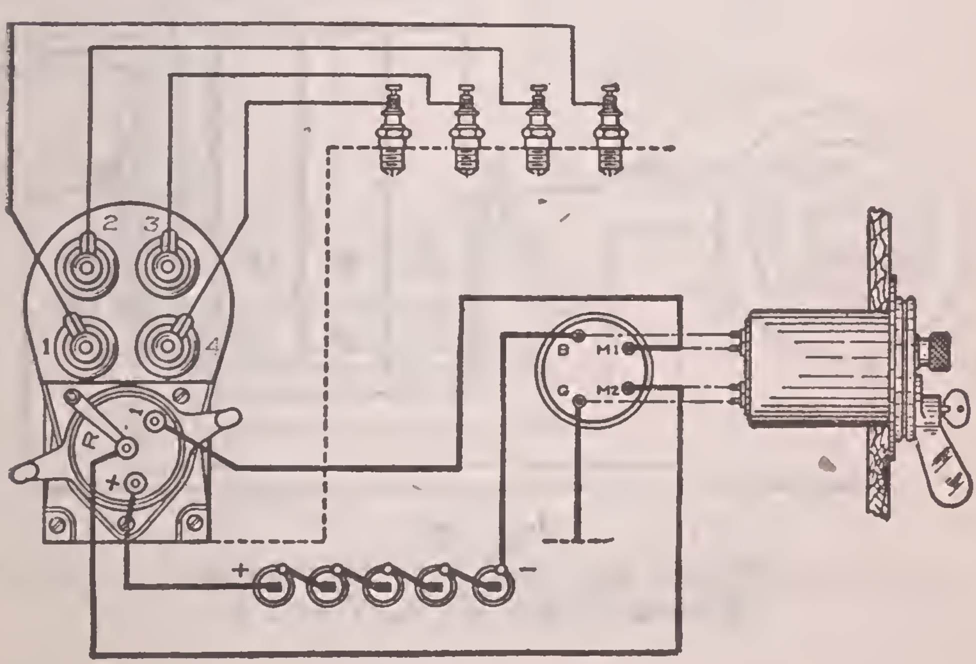


Fig. 226
Wiring for Simms Magneto Model SU4-S

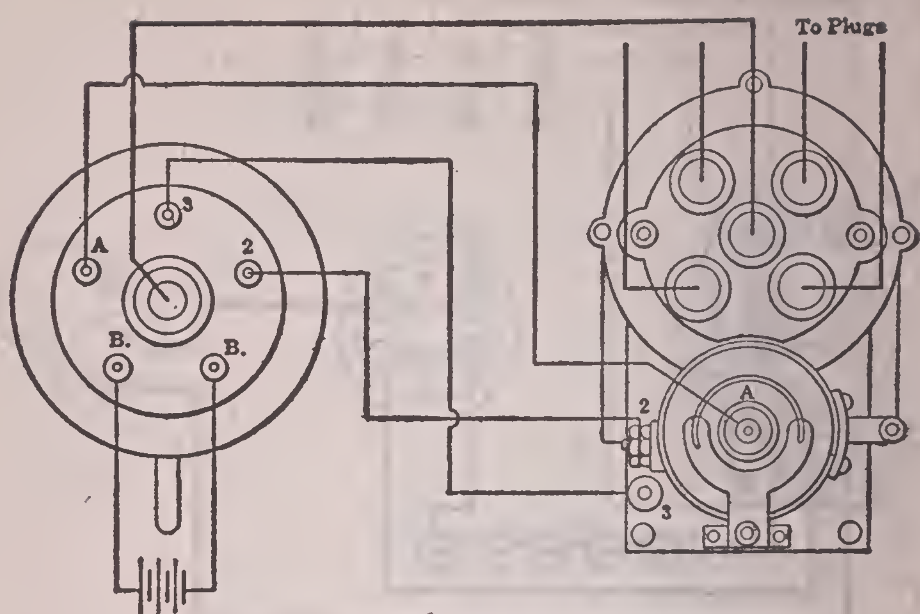


Fig. 227
Wiring for Splitdorf Magnetos,
Models A, B, D, F, O and T

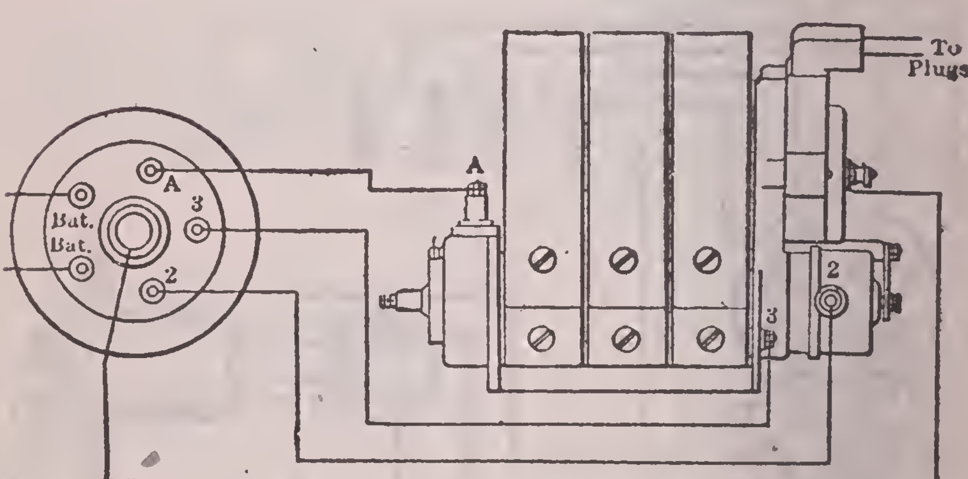


Fig. 228
Wiring for Splitdorf Magnetos,
Models S, SS, W, X, Y and Z

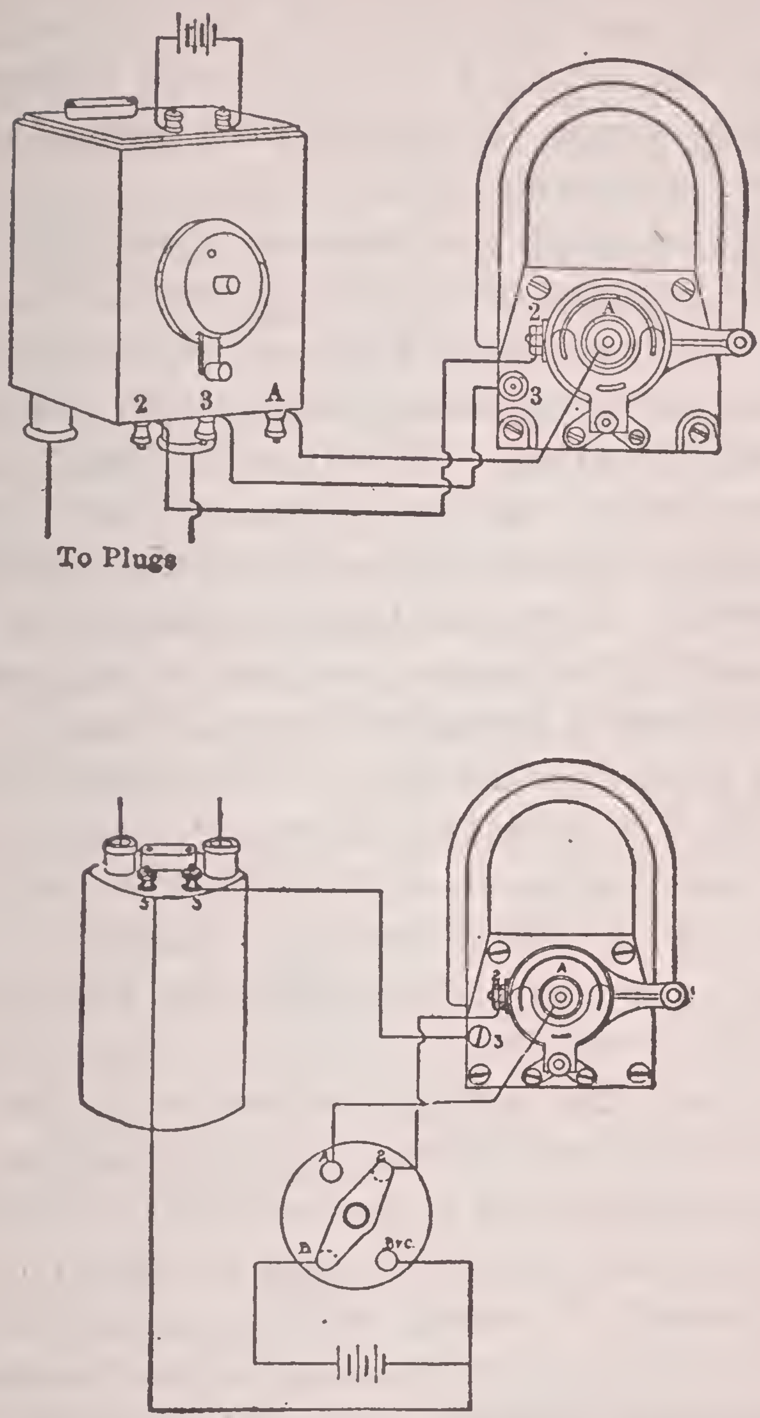


Fig. 229
Wiring for Splitdorf Magnetos With Dash and Tube Transformers

Induction Coil. The form of coil generally used on gasoline cars is known as the jump-spark coil. It is of two types, one known as a plain or single jump-spark, the other as a vibrator or trembler coil.

A jump-spark coil consists essentially of a bundle of soft iron wire, known as the core, over which are wound several layers of coarse or large size insulated copper wire, called the primary winding. Over this are again wound a great many thousand turns of very fine or small wire, known as the secondary winding.

Inertia. Inertia is that property of a body by which it tends to continue in the state of rest or motion in which it may be placed, until acted upon by some force. As used by the non-technical, it is almost universally employed in the former sense, i. e., that of the resistance which a body offers against a change in its position, an inert body usually being intended, so that the definition is perfectly correct so far as it goes. The popular impression is that only inert bodies have inertia, it being likewise generally thought that a moving body is possessed of momentum alone, whereas an object at rest is possessed of inertia, and the same object in movement has both momentum and inertia.

Insulating Material. Asbestos, lava, and mica are severally used for the insulation of spark plugs and sparking devices.

Vulcanized fiber or hard rubber or even hard wood are used for the bases of switches, connection boards and other places.

India rubber, or gutta-percha form the basis of the insulated covering of wires used for electrical purposes. The coils of small magnets and the cores of induction coils are usually wound with cotton covered wire, or in some instances the fine wire is silk covered, as in the case of secondary or jump-spark coils.

Joints, Ball and Socket. To produce a flexible joint capable of operation within certain limitations in any direction, the ball and socket form of joint is generally used on the ends of the rod which connects the arm of the steering mechanism with the steering lever attached to the hub of one of the steering pivots of the front axle.

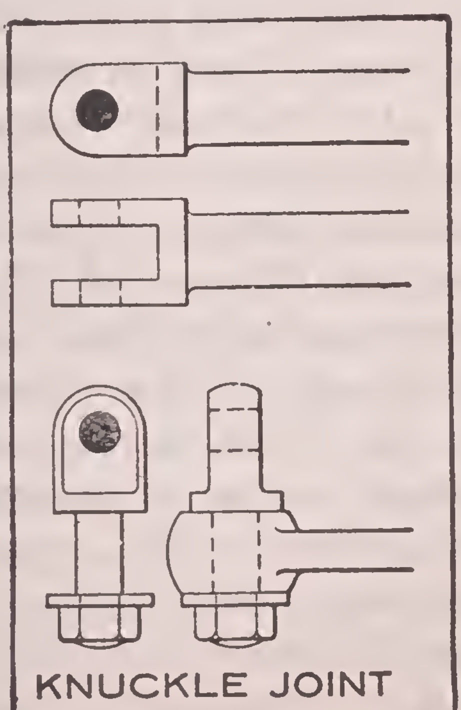


Fig. 230

Joints, Knuckle. Swivel or knuckle-joints for connecting the steering arm of the wheel, or lever steering mechanism to the arms on the knuckle-joints of the steering wheels are of various forms. Figures 230 and 232 show knuckle-joints which may be used for the above purpose. They are of simple construction and practically inexpensive to make. They may be used with any standard drop-forged jaw-ends.

Joint—Universal. The elementary form of a universal-joint or flexible coupling consists of a spiral spring. Such a form of universal-joint is sometimes used to drive a rotary pump, or a small generator on a car. The rear wheels or axle of a car are sometimes driven by means of a longitudinal shaft with a quarter-turn drive on a counter shaft, or a bevel gear drive attached to the differential gear of the rear axle. In such cases some form of universal-joint is necessary to allow the rear wheels and axle to accommodate themselves to the inequalities of the road surface. Three forms of universal-joints are shown in Figure 233 The upper view in the drawings shows the form most generally used on motor-cars, for the purposes just described. The one shown in the center view will allow a greater amount of angular distortion than the form shown in the upper view, but is of a more expensive construction. Where only a slight amount of angular distortion is needed, the construction shown in the lower figure in the drawing is very suitable, the two jaws or knuckles of the joint being flexibly attached by means of a plate of spring steel.

A form of universal joint, or flexible coupling, of recent introduction, is that making use of leather or other flexible material securely fastened to two forked members in such a way that with the members placed at an angle to each other, power is delivered from one to the other through the flexible material that is fastened to both of them.

Large powers are transmitted in this way by using a ring of heavy material similar to tire fabric and fastening the couplings of the two shafts to this ring at alternate positions by secure fastenings and bolts. The difference in alignment is taken care of by the ring of flexible material, and it has been found that this form of drive is quite free from trouble, and, of course, requires neither lubrication or covering against dust and dirt.

The flexible disc universal is largely used on motor trucks where the angle between the shafts to be joined is comparatively small and not subject to any great variations in angularity. The number of discs may be made in proportion to the load to be transmitted.

The form of compensating joint shown in Figure 231 may be operated with the axes of the shafts at an angle to each other, or with the shafts out of alignment with each other in vertical or horizontal parallel planes, and has quite a range of operation with either condition. Both

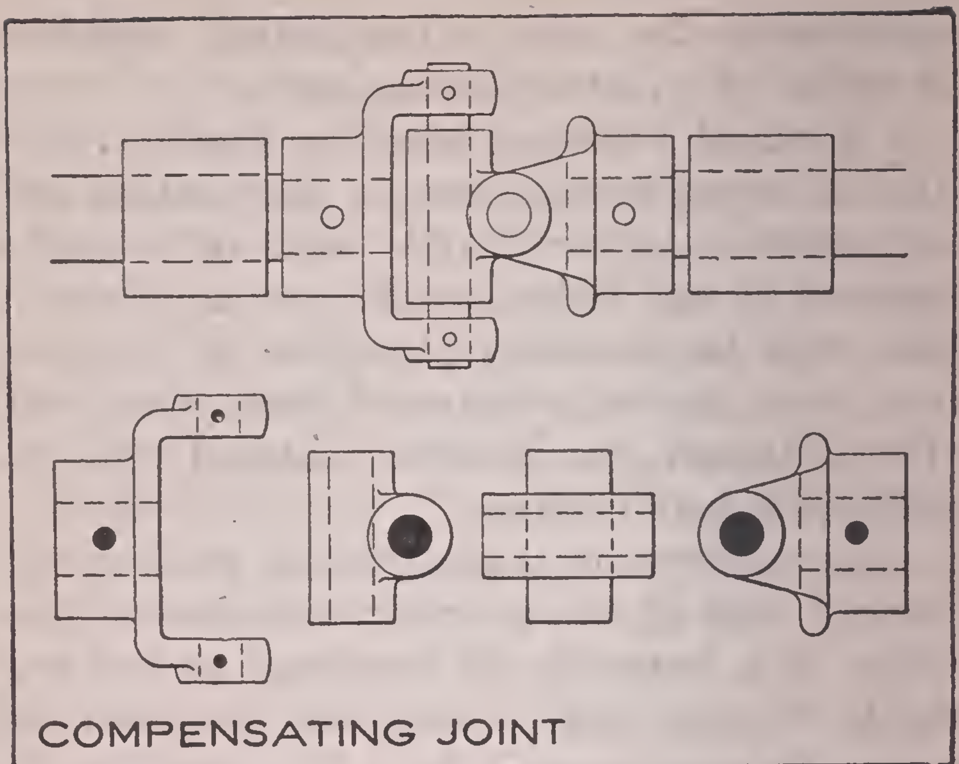


Fig. 231

forms of the device require to have bearings on either side, as shown, to insure their proper working.

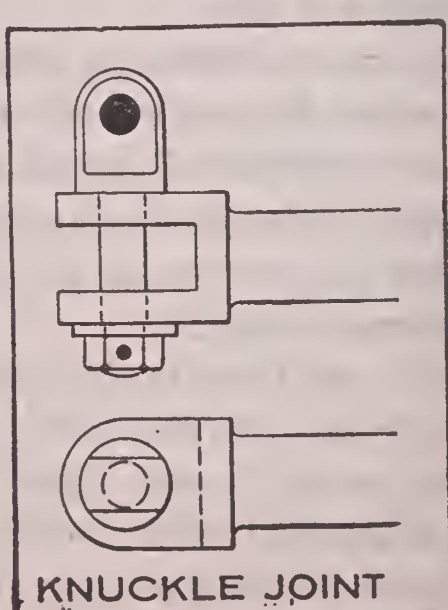


Fig. 232

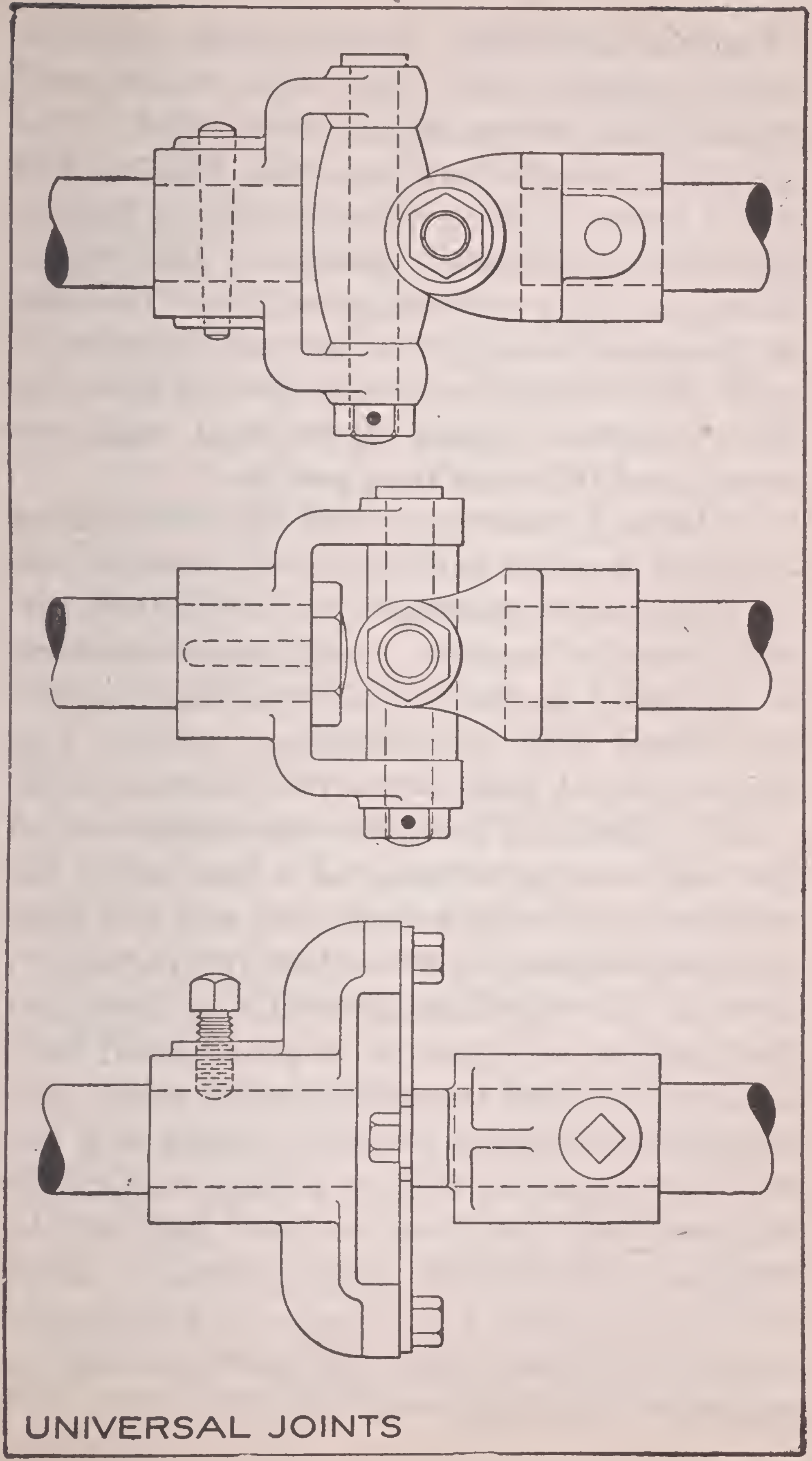


Fig. 233

Kerosene as a Fuel. Kerosene has been used as an explosive power, and crude petroleum is gaining favor as an efficient liquid fuel. With a specific gravity varying from 0.78 to 0.82, and a vapor flashing point at 120 to 125 degrees Fahr., kerosene ignites at 135 degrees Fahr., and boils at 400 degrees Fahr. Its vapor is five times heavier than air, and requires 76 cubic feet of air to one cubic foot of vapor for its combustion, giving 22,000 heat units per pound, or 4,000 more than gasoline.

In using kerosene as a fuel for the ordinary types of gasoline engines it will generally be found that the compression may be slightly lowered to good advantage. A high grade of rather heavy bodied oil must be used and the oil should be drained from the crankcase and the case washed out at least every five hundred miles.

It is difficult, if not quite impossible, to start the engine using kerosene as a fuel unless the cylinders and cooling water are still hot from previous running. Carburetors for the use of kerosene are therefore generally so arranged that gasoline, or a mixture of gasoline and kerosene, may be used for starting when cold. Two separate carburetors, joined by means of a two way valve, may be used or a single carburetor with two float bowls, one for each fuel, may be employed. Still other types provide a small amount of gasoline which burns for a minute or two after starting. The fuel itself, also the incoming air should be well heated.

Water vapor from an additional jet may or may not be used with the kerosene mixture. Under heavy loads at low speeds water may be added to the mixture with good results in preventing preignition.

Knocking—Locating Cause of. Tracing a knock is sometimes a puzzling job. It may be in one of the main bearings of the engine, in the camshaft bearings, in a loose valve lifter, in a loose camshaft gear key, in a loose pump or magneto drive coupling, an unsuspected loose bolt between two parts supposed to be fast, or in any of a dozen, or score of other unsuspected places. A valuable aid in locating a mysterious knock is a flexible speaking tube such as is used with phonographs. One end of such a tube can be held to the ear and the other moved about from point to point until the exact spot is found where the noise is loudest. Another aid is a light bar of iron, one end of which is pressed against the part where the knock is suspected and the other touched to the forehead or the teeth, when the sound is clearly transmitted.

Knocking or pounding is an inevitable warning that something is wrong with a motor. It may be due to any of the following causes:

Premature ignition: The sound produced by premature ignition may be described as a deep, heavy pound.

Using a poor grade of lubricating oil will cause premature ignition. The carbon from the oil will deposit on the head of the piston in cakes and lumps, and will not only increase the compression, but will get hot after running a short time and will ignite the charge too early, and thereby produce the same effect as advancing the spark too much. If this is the cause the pounding will cease as soon as the carbon deposit is removed from the combustion chamber.

Badly worn or broken piston-rings.

Improper valve seating.

A badly worn piston.

Piston striking some projecting point in the combustion chamber.

A loose wrist-pin in the piston.

A loose journal-box cap or lock-nut.

A broken spoke or web in the flywheel.

Flywheel loose on its shaft.

If the spark plug be placed so as to be exactly in the center of the combustion space, an objectionable knock occurs, which has never been fully explained. In some motors it renders a particular position of the spark control lever unusable; this form of knock disappears either on making a slight advance or retardation of the ignition.

Explosions occurring during the exhaust or admission stroke. This is almost always due to a previous misfire, and it is prevented by stopping the misfires.

If the ignition is so timed that the gases reach their full explosion pressure during the compression stroke, that is, if the spark be unduly advanced when the motor is not running at a high speed, an ugly knock occurs, and great pressure is developed on the crank-pin bearing, wrist-pin, and connecting rod. The result may be the bending or distorting of the rod.

The crank-pin may not be at right angles to the connecting rod.

The bearings at either end of the connecting rod may be loose. A knock during the explosion stroke, and also at each reversal of the direction of the piston.

If the crank shaft is not perfectly at right angles to the connecting rod, the crank shaft and flywheel will travel sideways so as to strike the crank shaft bearings on one side or the other.

Lamps, Electric. The small incandescent lamps used for automobile lighting are almost invariably of the tungsten filament variety. Two types are in use, considered from the bulb standpoint, one of which exhausts the air from the bulb until a high degree of vacuum is secured, and the other one of which replaces the air with the inert gas, nitrogen. One is called the vacuum bulb and the other the nitrogen bulb. Two types of bulb base are in use, the single contact, in which one side of the circuit is secured through metal of the base, and the double contact with two insulated leads. Lamp bulbs vary in diameter from ¾ to 2-1/16 inches.

Lighting, see *Starting and Lighting Systems*.

Lubrication. To ensure easy running, and reduce the element of friction to a minimum it is absolutely necessary that all surfaces rubbing together should be supplied with oil or lubricating grease, but it is also a fact, not so well understood, that different kinds of lubricant are necessary to the different parts or mechanisms of a motor car.

As the cylinder of an explosive motor operates under a far higher temperature than is possible in a steam engine, consequently the oil intended for use in the motor cylinders must be of such quality that the point at which it will burn or carbonize from heat is as high as possible.

While a number of animal and vegetable oils have a flashing point, and yield a fire test sufficiently high to come within the above requirements, they all contain acids or other substances which have a harmful effect on the metal surfaces it is intended to lubricate.

Lubricating Oils. The qualities essential in a lubricating oil for use in motor cylinders include a flashing point of not less than 500 degrees Fahrenheit, and fire test of at least 600 degrees, together with a specific gravity of 25.8.

At 350 to 400 degrees Fahrenheit, lubricating oils are as fluid as kerosene, therefore the adjustment of the feed should be made when the lubricator and its contents are at their normal heat, which depends on its location in the car. Steam engine oils are unsuitable for the dry heat of motor cylinders in which they are decomposed whilst the tar is deposited.

All oils will carbonize at 500 to 600 degrees Fahrenheit, but graphite is not affected by over 2,000 degrees Fahrenheit, which is the approximate temperature of the burning gases in an explosive motor. The cylinder of these motors may attain an average temperature of 300 to 400 degrees Fahrenheit. So that graphite would be very useful if it could be introduced into the motor cylinder without danger of clogging the valves, and could be fed uniformly. These difficulties have not yet been overcome. Graphite is chiefly useful for plain-bearings and chains.

The film of oil between a shaft and its bearing is under a pressure corresponding to the load on the bearing, and is drawn in against that pressure by the shaft. It might not be thought possible that the velocity of the shaft and the adhesion of the oil to the shaft could produce a sufficient pressure to support a heavy load, but the fact may be verified by drilling a hole in the bearing and attaching a pressure gauge.

Roller and ball-bearings provide spaces, in which, if the oil used contains any element of an oxidizing or gumming nature, a deposit or an adhesive film forms upon the sides of the chamber, the rollers or balls, and the axle. This deposit will add to the friction, hence it is the more important to use a good oil, or a petroleum jelly in such bearings.

Air-cooled motors, being hotter than water-cooled, must have a different lubricant, or one capable of withstanding higher temperatures.

The effect upon animal or vegetable oils of such heat would be to partially decompose the oils into stearic acids and oleic acid and the conversion of these into pitch. Such oils are therefore inadmissible for air-cooled motor use.

Mineral oils are not so readily decomposed by heat, but at their boiling points they are converted into gas, and any oil, the boiling point of which is in the neighborhood of the working temperature of the motor cylinder, is useless, as its body is too greatly reduced to leave an effective working film of oil between the cylinder and the motor piston.

The essentials for the proper lubrication of air-cooled motors are:

That the oil should not decompose.

That it should not volatilize, as this will result in carbon deposits.

That its viscosity should be equal to that of a good steam engine oil at similar temperatures.

That it should be fluid enough to permit of its easy introduction into the cylinder.

That it will have no corrosive effect on the cylinders and no tendency to gum.

That it will not oxidize with exposure to air and light.

The specific gravity of an oil is the ratio of weight of a volume of oil to that of an equal volume of water.

The fire point is the degree of heat at which oil begins to burn with a steady flame.

The flash point is the degree of heat at which the oil begins to give a slight explosion or flash from the evolved gas when a flame is held close to the surface of the heated oil.

The cold point is the degree of temperature at which the oil begins to thicken from chilling.

The viscosity is the property of cohesion, or the ability of the particles of the oil to cling to each other; also adhesion, or the ability of the oil to cling to surfaces with which it comes in contact.

The meaning of the term "body," as used in describing oils, is the oil's power of resistance to pressure and high heat without breaking down and losing its lubricating qualities. An oil of good body spreads evenly over the surfaces to be lubricated and maintains an even thickness of film.

Flywheel Oiling Systems. In the Ford flywheel system of oiling illustrated in Fig. 234, the flywheel casing serves as an oil reservoir, and the rotation of the wheel throws the oil up into pockets, from whence it is conducted through pipes to the crank-case. The angle of the pipes is such that even on extreme grades there is sufficient drop to insure a flow of oil. A depression M is found in the crank case beneath each connecting rod, in order to limit the amount of oil carried in the crankcase, and also to insure an even level of oil within the case.

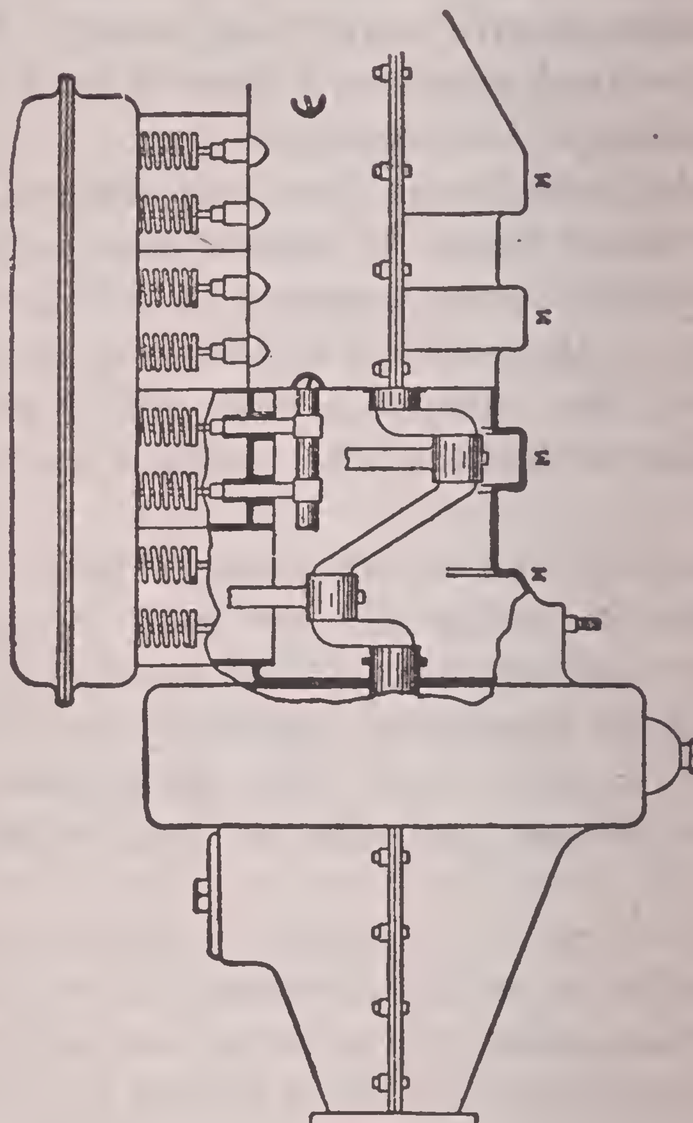


Fig. 234
Ford Flywheel Oiling System

DRILLING OIL PASSAGES IN THE CRANK SHAFT. Figs. 235 and 236 show two different methods of drilling the crankshaft to convey the oil to the crankpins, and it will be noticed that the oil holes discharge at the highest point of the revolution, corresponding to the position of the piston at the beginning of the power or firing stroke. The supply is received by the main bearings from the oil pump and the oil hole in the shaft, coinciding with that from the oiler has a little oil forced in each revolution and, generating centrifugal force throws it rapidly through the passages. The majority of modern motors are equipped with splash lubrication and have the connecting rods dip into the oil

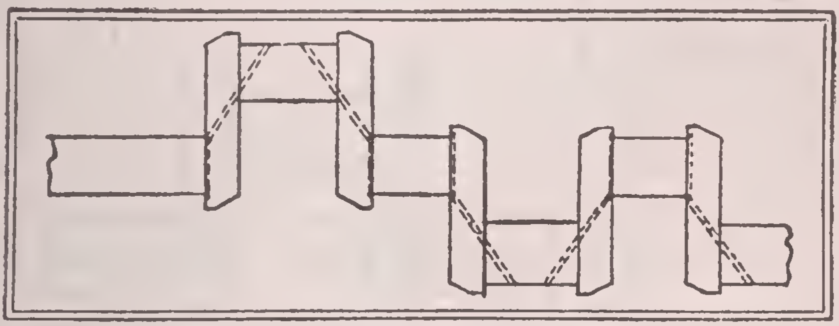


Fig. 235

each revolution and splash it all over the inside of the crankcase. Some types are equipped with a scoop pointing in the direction of rotation, at the lower end of a passage connecting with the crank pin. The oil is sent into these passages with considerable force, owing to speed of rotation, thus assuring sufficient oil to the connecting rod bearings.

This is worked to the ends of the bearing and thrown off in the shape of a fine mist that penetrates to every part of the crankcase. The oil splashed onto the lower cylinder walls and not carried up by the piston is caught in little troughs, cast in the crankcase and drilled so that the oil runs down to the main bearings. In addition to the pipe from the oiler, the better designs provide an oil wick, or an oil ring or chain, all types carrying oil from a shallow pocket corded in the bearing cap, the wick by capillary attraction, and the ring or chain, revolving with the shaft, their lower ends immersed in the oil will carry up a considerable quantity that will spread over the shaft. This

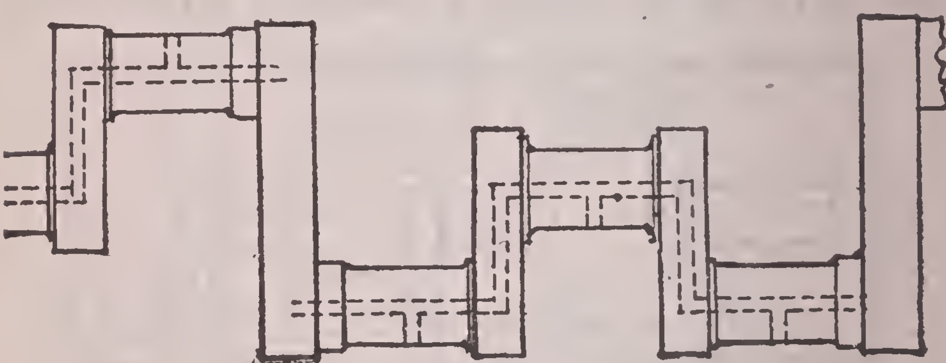


Fig. 236

oil ring system is used very successfully in electrical machinery. With a splash lubrication it is advisable to drain the crankcase at frequent intervals, and also to put in a fresh supply of oil.

Care should be exercised to select heavy oil for air-cooled engines or old engines, and a comparatively light oil for new cars.

Cylinder Oil Testing. There are really two parts to the fire test, as it is called. One is the test for flash point. This may be determined as follows: Take two pieces of glass of the same size, and large enough to cover a small glass beaker. In one of them cut a couple of notches. These are for two purposes. One is for the thermometer and the other for the flash point determination. Insert a thermometer in the beaker, filled with the oil under test. Place the notched glass over this and the other piece of glass over that, taking care to cover the notch not in use. Now uncover this notch, note the temperature, and apply a lighted match to the opening. If nothing results, warm the oil slowly over a flame to a higher temperature and take another trial and reading. Continue the test until upon the application of the lighted match the oil vapor over the oil flashes. The thermometer reading at that point gives the flash point. The glass plates may now be removed, and heating continued. The match is applied at similar intervals, until finally the oil burns, which will usually occur at about 50 degrees above the flash point.

An additional test is for precipitation at a known temperature. This is also made in a beaker. Two ounces is the usual amount. It is heated to the desired temperature, at which the oil may change color, but must not show a precipitation. Still another good oil test is the evaporation test. This is the result of slow heating, and the usual specification is that the oil shall not lose over 5 per cent. of its volume when heated to 150 degrees Fahr. for 12 hours.

Lubricating Systems:

Full Force Feed. Oil is forced by pump pressure to the main bearings and, by means of drilled holes in crank webs, to crank pins and through hollow connecting rods, or oil pipes attached thereto, to the wrist pins. Oil returns to sump, or reservoir, and is circulated again.

Force Feed. Oil is forced by pump pressure, or the centrifugal force of the revolving flywheel, to main bearings and through drilled holes in crank webs to crank pins. The wrist pins and cylinder are supplied by oil thrown from connecting rods. The connecting rods do not dip. Oil returns to sump, or reservoir, and is circulated again.

Force Feed and Splash. Oil is forced by pump pressure, or the centrifugal force of the revolving flywheel, to the main bearings and through drilled holes in the crank webs, to crank pins. The oil from the main bearings falls to wells in the bottom of the crank case, or to adjustable troughs, into which the connecting rods dip and splash oil to all parts of the engine.

Splash. A constant level is maintained in the crank case by an overflow to the sump, or reservoir, below, whence the oil is circulated again.

Lubrication of Gears and Clutches. The modern ball-bearing gear box requires but little attention. Periodic filling with suitable lubricants is sufficient. On chain-driven cars the gears and differential are usually exposed by lifting one cover. On shaft-driven cars the differential and rear axle system requires a certain amount of attention, as too much oil in the differential is liable to leak through the axle sleeve and hub, usually getting on the brake drums. If this happens, the best thing to do is to jack the wheel up and squirt gasoline on the drum, slowly revolving it meanwhile. Manufacturers usually put a plug in the differential case showing the proper height at which to keep the oil level. The gear box should be kept a little less than half full. If too much is put in, the oil will be thrown out of the shaft and bearing housings, but a little leakage does no harm as there is always dust present and the oil leaking will serve to fill the crevices and make the case dust-tight. In regard to the wheels, universal joints, clutch, and many little places about the car, all need attention occasionally as almost any motor car driver knows.

The wheels should be cleaned and packed with grease once or twice a season, universal joints at intervals necessarily shorter. Latest designs provide for their lubrication through the shaft from the gear box. Earlier types are best packed in grease and enclosed in a leather boot. On many shaft-driven cars, where the shaft runs through a sleeve, daily attention should be given. The lack of a few drops of oil may rob the car of 50 per cent of its power. Multiple disc clutches use oil, or an oil and kerosene mixture, and the tendency seems to be for the oil to gum. Their action when slipping or dragging is sufficient indication as to when they are in need of attention. Leather-faced clutches will work much better when cleaned with kerosene and given a dose of neatsfoot or castor oil. The oil should be spread over the surface of the leather by using a long knife blade, or by running the motor for a few moments with the clutch released. When treating the clutch leather this way it is better to let it stand over night if possible, and with the emergency brake lever, or a block of wood against the pedal hold the clutch disengaged. A hand oil can with a long spout is almost indispensable, and the starting crank, the steering pivots and connections, and the spark and throttle connections, gear control and emergency brake levers, clutch and brake pedals, shafts and connections and the fan bearings will all work much quieter and sweeter for a few drops of oil regularly. It is the practice of drivers to fill the oil can from the cylinder oil supply and this practice is to be commended, as many lower grade oils contain acids enough to etch steel.

Gear Case and Rear Axle. It is a familiar fact that the gear case requires to be periodically emptied of oil, and the accumulated metal grit washed out before fresh oil is supplied. The same is true of the rear live axle casing, except that the gears in the axle do not clash and therefore do not wear out as fast as the change speed gears. At least once in a season the oil in the rear axle should be drained out, a liberal supply of kerosene introduced, and the axle jacked up while the engine is run to agitate the oil and wash out the differential, etc.

Magnetic Gear Shift. The electric gear shift may be said to consist of two units, the "shifting assembly," or group of magnets attached to the transmission case, and the "selector-switch," or push-button group, located on the top of the steering column. The electrical current required to energize the magnets is derived from a storage battery, Fig. 237, ordinarily supplied as part of the starting and lighting systems on all cars.

The selector-switch is made up of a number of buttons, one for each speed, and one for the "neutral" which has not electrical connection. There is also a button for operating the horn. These buttons are provided with arched, laminated contacts of copper, backed up with a steel spring and insulated from the button proper. The top of the switch carries a locking-plate for locking any button which may be depressed and also carries an interlock, which makes it impossible to press down more than one button at a time. At the bottom is a hard rubber base, which carries a copper contact for each button and a contact common to all speeds. It also serves as a base for the return spring provided for each button.

The wiring, Fig. 238, consists of a lead passing from each coil through a terminal block to

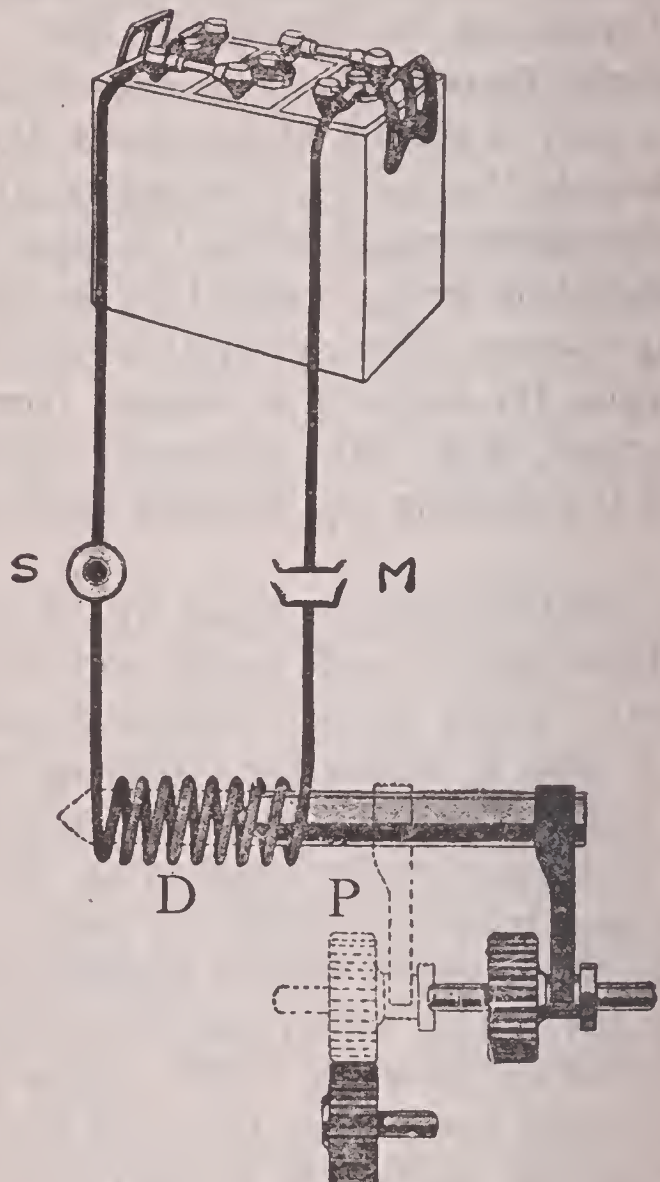


Fig. 237
Action of the Magnetic Gear Shift

its particular speed button on the selector-switch, while the other lead from the coil is joined to a neutral wire directly through the terminal block to the battery, with a master-switch intervening, while another wire from the battery passes through the terminal block to the contact of the selector-switch which is common to all speeds. The current travels from one terminal of the battery through the depressed push button on the selector-switch, down and around the coil selected, and then back to the other terminal of the battery.

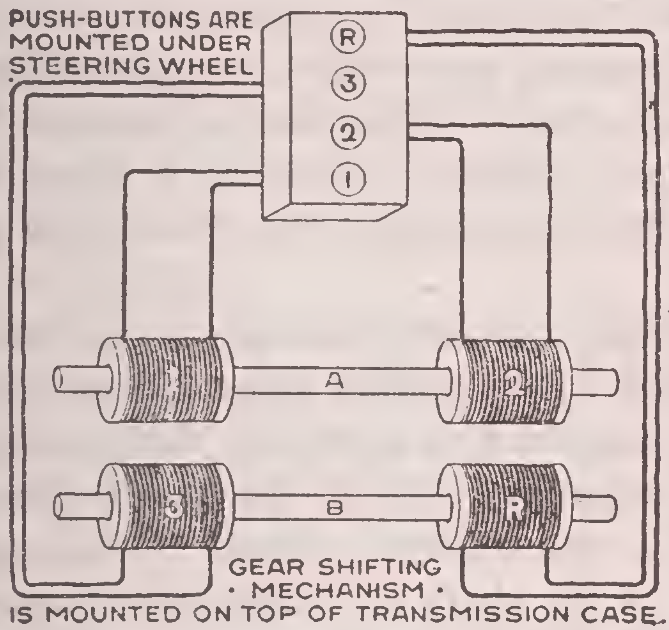


Fig. 238

Connections of the Magnetic Gear Shift

The Vulcan electric gear shift mechanism consists of a case which is attached to the transmission housing. This case, in turn, carries the magnets or solenoids. These in turn surround the plungers on which the shifting forks which move the sliding gears in the transmission are mounted. In this case, also, is carried the operating mechanism by means of which the gears are mechanically drawn to their neutral position through a connection with the clutch pedal. The case is divided into two compartments, the smaller of which is a pocket in which the operating mechanism for the neutralizing of the gears and the operation of the master-switch is carried. This compartment is entirely enclosed on the bottom, and is not open to the transmission case.

The neutralizing mechanism consists of two shafts on which cams are mounted. One of these shafts carries a pawl which engages with a latch on a rocker arm. Upon the opposite end of this rocker arm shaft is mounted a lever through which the connection with the clutch pedal is made.

Assuming that all gears are in a neutral position (that is, the sliding gears are not in mesh), and it is desired to start, the first speed button on the selector-switch is depressed, closing one break in the electric circuit. The operating lever and the shaft on which it is mounted are rotated and the master-switch is pulled into engagement through its connection with the operating mechanism which engages the switch stem. As the gear flashes into mesh, and is within 1/8 inch from being "home," the master-switch snaps out instantly, due to the action of the master-switch spring, thus breaking the electric circuit. The actual time of engagement during which current is being drawn from the battery is less than 1/3 of a second.

Being in first speed, and desiring to proceed to another, the other speed button upon the selector-switch may be depressed at the convenience of the driver. Then, when it is desired to shift, the clutch is fully depressed as before.

As the neutralizing cams rotate toward the center, they press against a boss on whichever side the gear is in engagement. This mechanically pulls the shifter fork and gear with which it is engaged back to neutral position, before the next shift can be made. The electric circuit is again made complete, the current flows from the battery through the solenoid selected and the proper gear immediately jumps into engagement. This action is the same for all speeds in the transmission.

Should it be desired to stop, the neutral button on the selector-switch is pressed. This action throws any other button which may have been depressed out of contact, that is, it automatically raises any other button which may have been depressed previously.

Any selection may be made, at any time, by pressing any push button on the wheel. This selection, however, does not necessarily influence the changing of the gears in the transmission. In fact, nothing happens until the master-switch is closed by the pressing, all the way down, of the clutch pedal.

In the operation of this device the clutch pedal may be slipped or fully released without any action taking place in the gear shift mechanism itself. This is due to the fact that the operating lever is attached to the clutch pedal by means of an operating rod provided with a link mechanism, which allows the clutch pedal to fully release the clutch before it starts to pull on the operating lever.

Magnetism. A piece of iron or steel may be made a magnet under the influence of another piece that is already magnetic or by being acted upon by the electrical influence from a conductor carrying current.

The magnetism in a piece of iron or steel is supposed to consist of a circuit and the path of this circuit through the magnet and the space surrounding it is called the path of the magnetic line of force.

These lines of force pass through the metal of the magnet from one end to the other and after issuing from the magnet, travel through the surrounding space to re-enter it again as shown in Figure 239. The end of the magnet at which the magnetic lines of force enter the metal is called the South or negative pole, while the end from which the lines of force issue is called the North or positive pole.

Magnetic lines of force reside in and act from iron and steel only, but they will pass through all other materials almost as though these other materials were not in their way.

A piece of hardened steel which has been made a magnet has the ability to retain its magnetism for a long period of time unless acted upon by outside forces such as heating or hammering. Such a piece of steel is called a permanent magnet.

These metals, when soft, carry the lines of force as readily as when hardened, but they remain magnetic and have the properties of magnets only while in the field of other magnets or of coils of wire carrying current which produces magnetism in the iron.

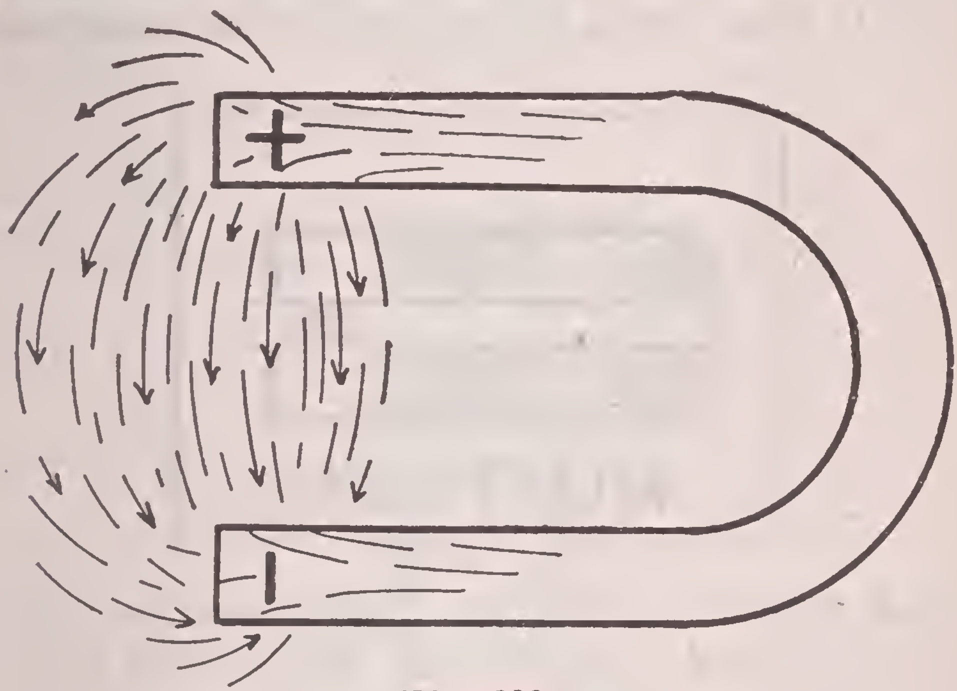


Fig. 239.

Magneto; see *Ignition, Magneto.*

Muffler, Exhaust. When the exhaust gases of an explosive motor are allowed to pass out through the exhaust pipe directly into the atmosphere, the sharp explosions rapidly succeeding each other are very annoying, and it is for this reason that the device termed an exhaust muffler is, or at least should be, used.

Various types of mufflers are in use, each no doubt possessing its own particular merit. The function of the muffler is to deaden the noise of the escaping gases, and the general requirements of the device are as follows: (1) It must be built strong enough to withstand the force of any explosion liable to occur within it, due to the escape of an unexploded charge, which may take place in one of the engine cylinders. (2) It must check the velocity of the escaping

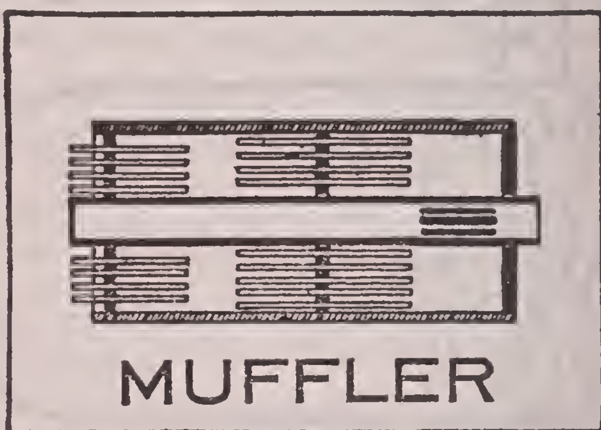


Fig. 240

gases without causing too much back pressure on the motor. (3) It must deaden the noise. The last two requirements may be attained by: (a) Breaking up the gases into a number of fine streams; (b) Allowing the gases to expand and cool; (c) Reducing the pressure of the gases, until they are as nearly as possible at atmospheric pressure.

The terminal or exhaust pressure ranges at from 30 to 50 pounds per sq. in. above atmospheric pressure, while the temperature will be 800 to 1100 degrees F.

MUFFLER CUT-OUTS. Mufflers are generally equipped with muffler cut-outs, which by-pass the gas so that it exhausts direct into the atmosphere with its attendant noise. There are three reasons why they are so equipped, namely: to tell if the engine is exploding regularly; to clean the exhaust pipe; to have it act as a safety valve in case of explosions in the muffler. If the power of the engine increases when the muffler is cut out, it is a sure sign that the muffler is of defective design or needs cleaning.

MUFFLER CUT-OUT VALVE. One form of cut-out valve is shown in Fig. 241. It is inserted in exhaust pipe P, by sawing a hole in its under

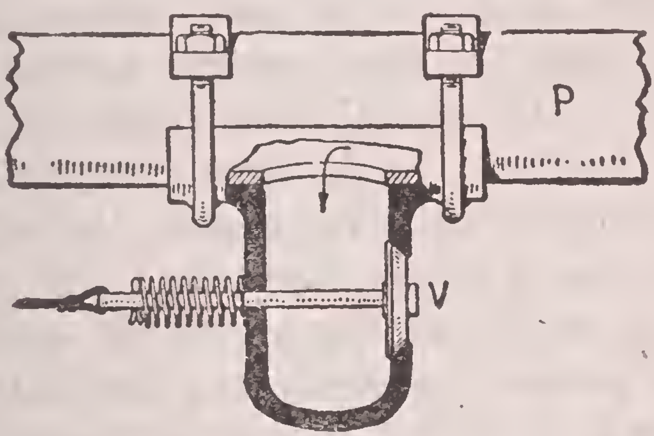


Fig. 241
Muffler Cut-Out Valve

side. The cut-out valve housing clamps to the pipe by a couple of V-clamps. The valve is carried in a cylindrical compartment under the exhaust pipe, and consists of a spring closed poppet valve a little larger in diameter than the internal diameter of the exhaust pipe. It opens against the exhaust pressure to prevent leakage.

Care of Mufflers. From time to time, all mufflers should be cleaned, because it will be found that they will contain a considerable amount of carbon deposists. These deposits not only tend to increase the back pressure, but they retain the heat of the exhaust, thus allowing the gases to escape at a higher temperature than they should. A muffler should be taken apart and cleaned once a year, or oftener if there are any indications of loss of power, resultant from back pressure.

A frequent cause of damaged or broken mufflers is the practice of ignition testing employed by some mechanics. In case of trouble with either source of ignition, the car is run at a rather high speed on the good system, and the ignition switch is then quickly turned to the faulty side. If no explosions result, the switch is again changed. In the time during which no explosions occurred in the engine, the unburned mixture was pumped back into the muffler. When the switch is thrown to the good side, the first power stroke sends a flame into the muffler with the result that an explosion occurs there, usually damaging the muffler seriously.

Packing. Packing or material for making gas, or water-tight joints is of various kinds. Asbestos packing comes in sheets, called asbestos paper or board, in the form of woven cloth, and also as string or rope. Rubber packing is made in sheets, either plain or with alternate layers of canvas and rubber. Some forms of packing are known as Rubberbestos, and Vulcabestos, and are made of asbestos, impregnated with rubber and afterwards vulcanized.

Picric Acid. Gasoline will absorb or take up about 5 per cent of its weight of picric acid. The addition of a small quantity of kerosene will enable the gasoline to absorb about 10 per cent of pircric acid.

Picric acid is only dangerous when fused, or when in a highly compressed state.

An increase in motor efficiency of about 20 per cent is claimed for the picric-gasoline mixture.

About three-tenths of a pound of picric acid is required for each gallon of gasoline. The mixture should be allowed to stand for two days, agitating occasionally during this time, then strain through two or three thicknesses of very fine muslin before using.

It must be remembered that picric acid is an etching ingredient, which is another way for saying that it will destroy the cylinder walls.

The explosive force of picric acid is very much overrated. If thrown upon a red hot plate of iron, it simply burns with a smoky flame, and striking a small quantity of it upon an iron anvil will not explode it.

Polarity. To ascertain the polarity of the terminals of a storage battery or light circuit, place the ends of the wires on the opposite ends of a small piece of moistened litmus paper. The wire on the side of the paper which has turned red is the negative pole of the battery.

Porcelain. Porcelain tubes used for the insulation of the center rod of a spark plug have higher insulative properties than lava or mica, but on account of the liability of the porcelain to break from too sudden change of temperature, it is not as reliable as other forms of insulating material.

Pounding—Causes of. The most obvious cause of pounding is that of a spark advanced too far. This, however, nearly always occurs upon hills, in deep sand or mud, or elsewhere, whenever the engine is laboring very hard. In the case of too far advanced spark, manipulation of the spark would only make the pound worse than ever. So, too, if the spark was normally set too far advanced, it would pound more at high speeds than at slow, just the reverse of the actual case.

Preignition causes pounding, and is itself caused by overheated piston or cylinder walls. Glowing points or deposits of carbon within the cylinder, as well as faulty or uncertain ignition also cause it. Leaks in the chamber are sometimes the cause of pounding, so too, are looseness of parts. Among the latter may be cited: connecting rod bearings, main bearings, loose flywheel, cracked flywheel, other lost motion. Beyond these things, the only other cause of pounding is that of some moving part which strikes as it rotates.

Preignition—Causes of. If the inside surfaces of the combustion chamber are free from sharp corners or projections formed in casting, preignition is probably due to the combined influences of high compression, and carbon or dirt on the piston head. Next to the exhaust valve itself the piston head is the hottest part of the engine, since it cannot be water cooled. For this reason it is much more important to keep the piston head clean than the other surfaces exposed to flame, and this is best accomplished, first, by the use of a good non-carbonizing oil, and, second, by thoroughly screening the air intake. If preignition is troublesome it will pay to fit a dust screen underneath the engine in case none is already provided, since whatever dust touches the piston head will be held there by the oil, and will be fully as effective in causing preignition as the same amount of carbon. The intake itself should draw air through at least one, and preferably two or more fine wire gauze screens of sufficiently large area to permit the air to pass through them slowly. These screens should be removable, and should be inspected, and cleaned with gasoline and a toothbrush as often as may be necessary. It will be found that the fitting of a suitable dust screen beneath will make an immense difference in the amount of cleaning, which the gauze screens require. In the manufacture of high classed motor cars the greatest care is taken in scraping the walls and dome of the cylinder castings forming the combustion space, the aim being to remove every projection that might cause a pre-ignition point as also to remove every burr, or rough spot to which foreign matter would adhere. The lubrication system of a car is a most important factor in the elimination of preignition due to the proper amount of oil being fed to the cylinders.

When a back kick occurs and the crank-shaft rotates in the reverse direction, that rotation must first be stopped and a rotation started in the correct direction. To stop the back kick or reverse rotation requires power, and to again start the correct rotation calls for power. The forces that stop the back kick are, the arm of the person cranking the weight of the rotating flywheel, and forcing one of the other pistons to compress the mixture. The force that starts the flywheel in the correct direction is the exploding charge of gas in cylinder No. 2 as illustrated in Fig. 242, in which the piston in No. 1 cylinder has not reached the top dead center on the compression stroke when the spark occurs and the reverse movement of the crankshaft starts. In tracing out what happens the valve locations must be considered. Both valves—intake and exhaust—in No. 1 cylinder are closed on the compression stroke and they will remain closed on the back kick stroke. Had the motor been running, No. 2 cylinder would have been going down on the explosion

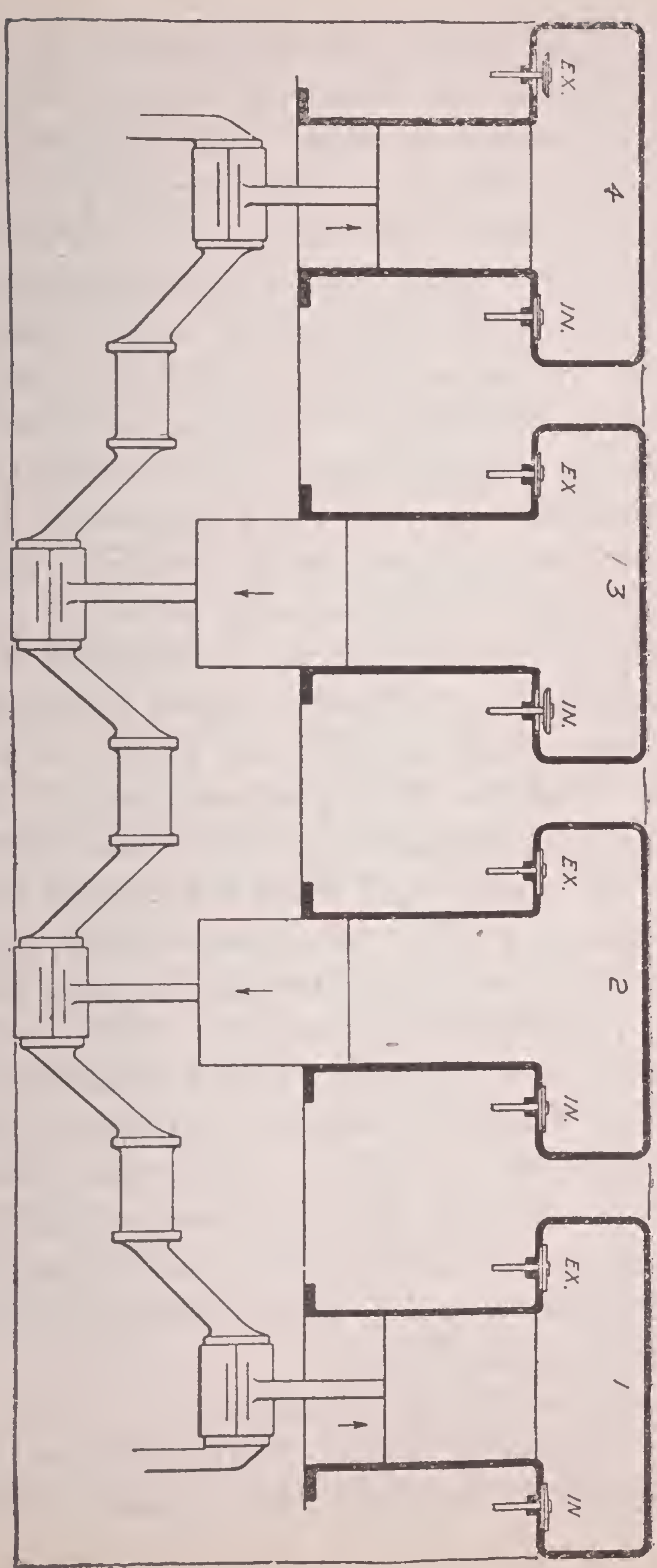


Fig. 242
Diagram Illustrating Theory of Back Firing

stroke of the piston, but as there was no previous explosion, the motor having been idle, the cylinder would be filled with mixture, with both valves closed, as they always are on the explosion stroke. The piston in this cylinder was normally going down; but, as soon as the back-fire occurred, the piston would start up and the valves remaining closed, the mixture would be compressed. This pressure would help to stop the back kick, and as soon as the power of back-kick was over the compression would start the piston down on the proper explosion stroke, which would prove of sufficient power to carry the motor past the firing point in the other cylinders. Cylinders 3 and 4 would not be factors at all, in that the piston in No. 3 would, when the back-kick occurred, be near the bottom or end of the suction stroke with the intake valve open, and when the reverse action of the piston set in it would start rising, simply driving the mixture out through the open intake valve and through the carbureter. Cylinder No. 4 was near the completion of the exhaust stroke when the back-fire started, and the exhaust valve was open. During the reverse motion caused by the back fire, the piston would start descending, the exhaust valve remaining open, exhaust gases would be drawn into the cylinder from the exhaust pipe.

Other causes of back firing are,

(1) A WEAK MIXTURE. Bearing in mind that the mixture is the fuel of the engine, and that

as in a stove, the character of the fuel influences its manner of burning, it will be evident that like poor wood, slaty coal, or other imperfect fuel, a weak mixture is a slow burner. This is point number one. Proportionate to the speed at which it is running, the motor has a certain sharply defined period of time in which it must complete each part of its cycle, if it is to operate satisfactorily. Should the parts of the cycle lap, or run over into one another, there is bound to be a hitch of some kind. The use of a very weak mixture causes just such a hitch by reason of the fact that it continues burning for some time after the completion of the part of the cycle during which it is supposed to function, i. e., the power stroke. In fact, it is still burning when the inlet valve opens to take in a fresh charge, and as its burning in the cylinder maintains considerable pressure therein, the latter, on the lift of the inlet valve, escapes through it and the carbureter with a pop, exactly similar to that of an unmuffled exhaust except that it is weaker. The remedy is more gas or less air, or sometimes both, and to find out just how much of each is required, start the motor and very gradually cut down its gasoline supply at the needle valve of the carbureter until the motor begins to miss. Then as slowly increase the supply until the motor will run steadily and without missing on the minimum opening of the needle valve. Lock the latter in place. Then speed the motor up by opening the throttle and adjust the spring of the auxiliary intake on the carbureter until the motor is receiving sufficient air to enable it to run and develop plenty of power at all speeds.

(2) An overheated combustion chamber, due to a poor circulation of the cooling water—causing self-ignition of the charge before the proper time.

(3) Advancing the ignition point too far ahead when the motor is running slowly under a heavy load—flywheel has not sufficient momentum to force the piston over the dead center, against the pressure of the already ignited and expanding gases.

(4) The presence of a deposit of carbon (soot) or a small projecting surface in the combustion chamber which may become incandescent and cause premature ignition.

Repair Work. In assembling the car the engine had best be put together first. When putting the pistons in their respective cylinders see that the splits or joints in the piston rings are not in line, but are spaced evenly around the piston. See that all parts are thoroughly clean and that no grit, or stray strands of waste happen to be caught on any projection. All nuts and bolts should be screwed tight and the jaws of the wrench should be properly adjusted to them, that the corners of the nuts and cap screws may not be rounded off. Insert the cotter pin after each nut has been screwed home. In joints where packing is required the old packing may be used if it is in good shape. Joint faces should, of course, be perfectly clean. A stout grade of manila wrapping paper soaked in linseed oil will make an excellent packing for crankcase and other joints having a good contact surface.

While the engine is being reassembled it will be found advantageous to check up the valve timing. To do this, turn the fly-wheel until the inlet valve plunger of No. 1 cylinder just touches the lower end of its valve stem. At this point the line on the fly-wheel indicating "Inlet No. 1 Open" should coincide with the pointer on the engine base. If the contact between the valve stem and the plunger is made before the mark on the fly-wheel lines up with the pointer, the valve opens too early. In most cars the adjustments may be made by the screw cap and lock-nut on the plunger. As the valve stems are lowered by repeated grindings of the valves, the plungers require adjustment occasionally to compensate for this movement. Insert a piece of paper between plunger and valve stem, and by lightly pulling on the paper the time of contact and the moment of release may be determined to a nicety. When the paper is held tightly, a good contact is assured, and the moment the paper becomes loose and can be moved about, the contact is broken. In many cars the reference or index mark on the engine bed is omitted; in this case the markings on the flywheel must be brought directly to the top. The other inlets and the exhaust valves should then be similarly checked up and adjusted.

Most cars base the valve setting on a 1-32 inch clearance space between valve stem and plunger rod when the valve is closed. This may be taken as the minimum amount, and should not be increased. A larger amount of clearance will cause the exhaust valve to open too late, and, the exploded gases not being entirely expelled, the power of the motor will be impaired. This clearance is necessary to allow for the expansion of the valve stem when it becomes heated.

Too much stress cannot be laid on the necessity of going about the work in an orderly and methodical manner. A mechanic who leaves parts lying about carelessly will rarely be found a good one, and certainly he is not a proper model to copy. With care, the amateur owner should have no trouble in overhauling, thus bettering the condition of his car and acquiring a valuable stock of knowledge.

AUTOMOBILE TOOLS. In Fig. 243 three types of valve lifters are shown. B and C are of the same principle, and quite efficient in almost any case; but A, when properly operated, and on its respective motor, is more quickly applied,

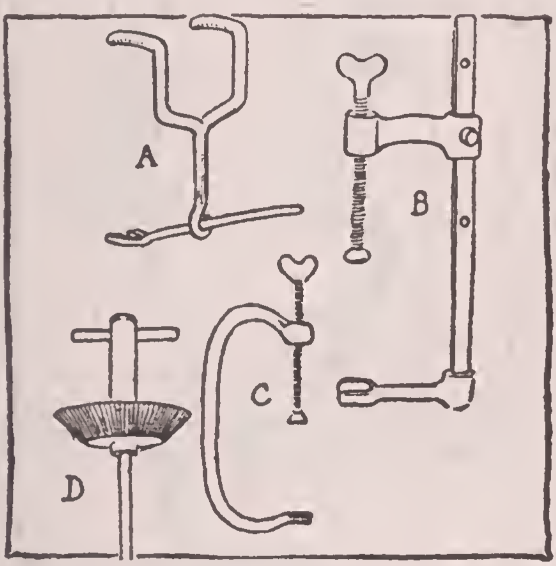


Fig. 243

and consequently a time saver. D is a valve-seating tool, supplied as special equipment by one of the large motor car manufacturers.

In Fig. 244 are shown a couple of spanner wrenches and one or two other tools that are quite uncommon but quite necessary in the work to which they are adapted. A is made from a piece of steel tubing and used on packing glands—the tube to slip over the shaft—and the small lugs at the end engage corresponding recesses in a packing nut. B is representative of a valve-grinder, designed especially for the valves in certain motors. The spanner C is required to conveniently remove certain types of cylinder plugs; while D, which approaches the conventional, is used in adjusting bearings of a particular type.

There is probably a greater variety of wheel and gear pullers now in service than of any

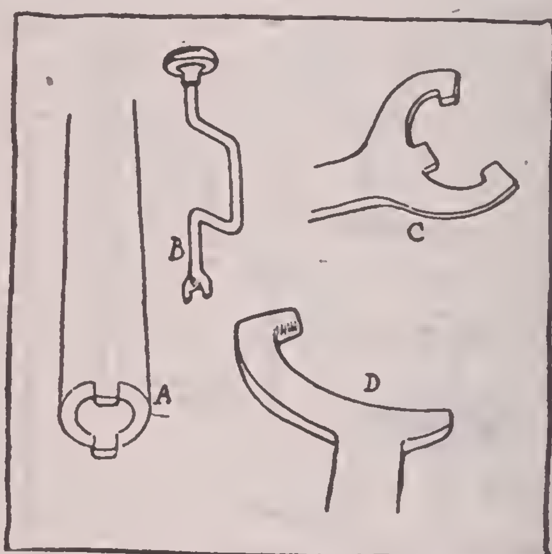


Fig. 244

other special tool. In Fig. 245, A looks very much like the standard adjustable wheel and gear puller for sale in all supply houses; and it practically is the same except that the hooks are larger and twisted in opposite directions and at right angles to the beam. It is found useful in removing road and flywheels and the like. B is a non-adjustable tool made especially for removing flywheels. C and P are road wheel pullers, and are included in the regular equipment of tools supplied with the cars of two prominent manufacturers. C is part of the Rambler tool equipment and is used in connection with their spare wheel; and P represents the type of wheel puller supplied by the Pierce-Arrow. E is a gear-puller designed to remove the half-time-gears of an Oldsmobile, the two

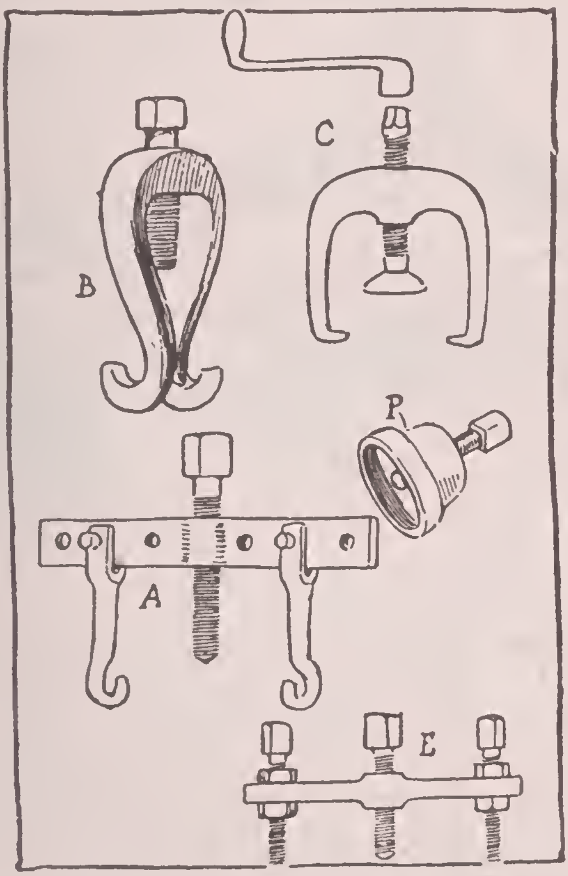


Fig. 245

side-screws being intended to fit into threaded holes in the web of the gears.

REMOVING DENTS. An easy method of removing dents consists of soldering a piece of wire to the bottom of the dent, then pulling the depressed portion out to its proper position. When the dent happens to be in an oil, or gasoline tank, or a radiator, an old valve can be most effectively used in place of the wire, as shown in Fig. 246.

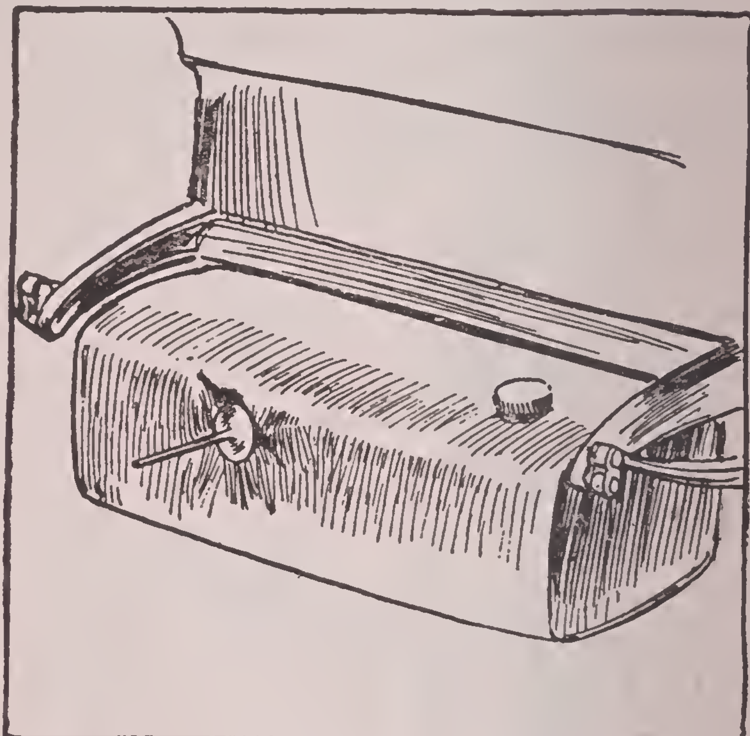


Fig. 246
Removing Dent in Gasoline Tank

TOOLS NECESSARY. The following tools should be in the car when on the road:

Monkey wrench, 9 inch.
Machinist's screwdriver.
Ball pene hammer, one pound.
Combination pliers, 8 inch.
Set of double end, or "S" wrenches.
Flat file, mill cut.

Three cornered file.
Round file, six inch.
Center punch.
Prick punch.
Drift punch, flat ended.
Offset, or "bent-end" screwdriver.
Cold chisel, three-quarter inch.
Spark plug wrench.
Small wire cutting pliers.
Emery cloth.
Cotter pin puller.
Wire brush for spark plugs.

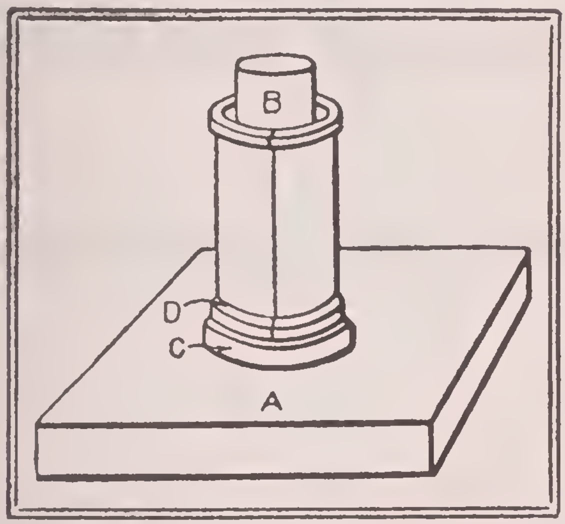


Fig. 247
Pouring Parson's Metal

Shop Kinks. To reline a journal box with Parson's white brass, proceed as follows: Prepare a reasonably smooth cast iron plate A, Fig. 247, which is bored to receive a vertical mandrel B about 3/16 inch smaller in diameter than the finishing bore of the box. An annular brass ring C, about ½ inch wide, and whose inside diameter is about ⅛ inch smaller than the outside diameter of the end flange D of the box to be lined, is then located on the iron plate concentrically with the mandrel, and secured by means of pins or otherwise. This ring serves as a support for the box itself, and in the process of pouring, the space between the ring and mandrel is filled with white brass which is afterward turned off. Any imperfect metal which may be poured will

Fig. 248

find its way either into this space or into the space above the box, leaving the lining of the box itself perfectly sound. The box itself is assumed to have been suitably counterbored and recessed to hold the lining as shown in the sketches E and F, Fig. 248. It is preferable to use the arrangement shown at F and allow the lining to extend beyond the ends of the box, and form the outer surface of the flanges. In this case the diameter of the flange formed by the lining will be the inside diameter of the supporting ring, which will be slightly smaller than the diameter of the flange of the box itself.

The halves of the box—if it is split—are wired together and the box and the mandrel are heated by torches and assembled as shown in the sketch. A second ring—not shown—similar to the supporting ring is placed on the top of the box, and all the cracks are luted with moist fire clay. Meanwhile, the white brass has been melted in a kettle to a fairly high heat somewhat higher than the pouring temperature. While it is being melted, it is kept covered by about 1 inch of powdered charcoal, which excludes the air. When the maximum temperature is reached, the charcoal is quickly skimmed off and a handful or two of powdered salammoniac is thrown on. The salammoniac is immediately volatilized and forms a heavy, though colorless gas which shuts off the air from the surface of the metal and causes it to stay bright. The pouring is then done with all possible haste, and on cooling the metal will be found perfectly homogeneous and solid. If the box is split the lining can be condensed by pening. If the box is solid, the lining is simply bored to the proper size.

To Restore a Sagged Frame. A frame which is sagged to the extent of permanent deformation can be restored so as to approximate its original shape, by heating it in a charcoal fire with an air blast. To do this properly, it will most likely be necessary to cut out the rivets, so that the side members can be handled independently. A good plan of procedure is to inclose the bent portion of the frame in a section of stovepipe of sufficient size in which the charcoal fire is built. A length of 1-inch gas pipe, closed at one end, and having 5/16-inch holes, drilled at intervals of about 6 inches, is laid in the bottom of the pipe and furnishes the air supply from a bellows. When the charcoal fire is well kindled, the frame is introduced upside down, and is supported at the ends. The fire is then concentrated on the bent portion, and as the frame becomes hot it will straighten itself. It must be watched carefully and the air blast stopped as soon as the frame is seen to be straight. Most of the frames used in American cars are ordinary carbon steel, and require no special treatment. It will be well, however, on stopping the air blast to shift the stove pipe to a cooler portion of the frame, to permit the part which has been straightened to cool as quickly as exposure to the air will permit. A frame which has been sagged and straightened in this manner will require to be trussed to prevent recurrence of the trouble. As conditions vary so much the best rule to follow is to observe the truss arrangement on some similar car. The struts should be about 4 or 5 inches long, and should be located at the spots where the sagging has occurred. The truss rod itself should be about ½ inch in diameter, and drawn taut by a turnbuckle, which may be finally tightened when the chassis has been assembled.

SPANISH WINDLASS. The old fashioned Spanish windlass, in Fig. 249, may be occasionally employed where no other hoist is available. It is extremely handy in setting, and lining up motors, transmissions and rear axles. It consists of a round bar or piece of pipe, a piece of rope, and a lever such as a small crowbar or

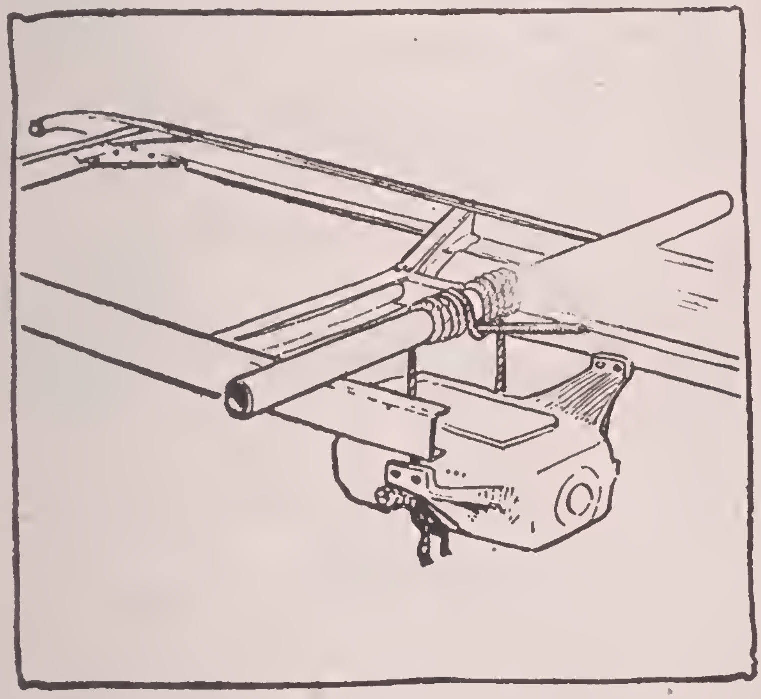


Fig. 249
Spanish Windlass

jack-handle; all of which are quite common to the ordinary repair shop. The round bar is laid across the side members of the frame, the rope is made fast to the object to be hoisted, a loop of it is wound around the bar as shown, and the lever inserted in the end of the loop. Although this is as old as the hills, it is not uncommon to see a man lying on his back, in a most uncomfortable position, holding a heavy transmission case up into place while another is trying to locate the bolt holes, and adjust the liners; whereas, if this makeshift windlass were employed, one man could raise and set the gear-box with much less trouble.

STRAIGHTENING SPINDLES. In Fig. 250 a tool is shown which is used in a local repair shop, for straightening spindles. The tool, which is of heavy construction, is placed in a vise; the

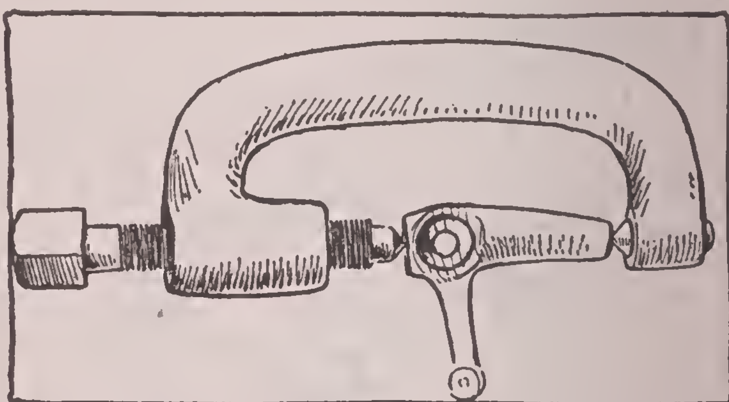


Fig. 250
Tool for Straightening Spindles

spindle is heated to a red heat, the ends cooled off with water, and placed between the centers, as illustrated. A lever is then placed between the bent portion of the spindle and the shank of the tool, so that when pressure is brought to bear on it, the spindle arm may be brought back into its normal position.

CLEANING ALUMINUM. Aluminum, such as used for foot-boards of cars, may be cleaned by using hyposulphate of soda, as this substance is a solvent of aluminum tarnish. The dirty sur-

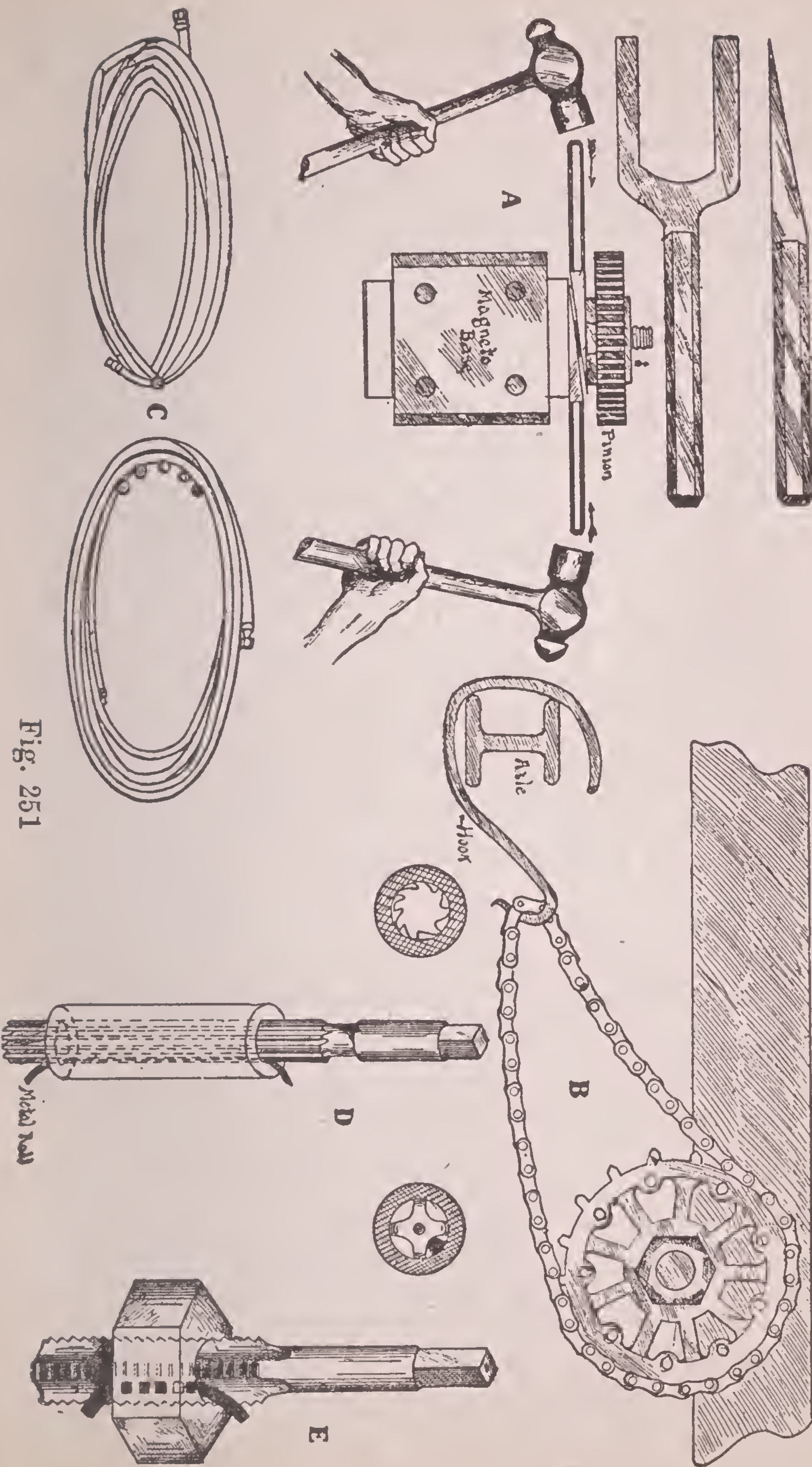


Fig. 251

face should be washed with a strong solution of the hyposulphate; then rinse the surface with water and dry.

Care of Tire Pump Leather. The proper lubricant for the cupped leather washer of the tire pump piston is vaseline. Oil is too thin and it tends to work into the rubber hose, and even into the tire itself if too much is used. Vaseline, on the other hand, clings to the leather and lasts a considerable time. If the leather becomes dry it does not hold air well, and pumping to high pressure becomes impossible, while the labor of pumping even to low pressure is greatly increased.

Replacing Broken Ball. When replacing a broken ball in a ball bearing it is better to renew the whole set, unless the new ball can be carefully gauged to be of the same size as the others. If this is not attended to, the new ball, having to bear more than its share of the weight, quickly succumbs. The greatest care should be taken, of course, to use grease free from grit, and to clean the balls and bearings before they are replaced.

Cleaning Tops. Tops may be cleaned by using gasoline, a little ivory soap and a brush. Sometimes, however, when cleaning with gasoline the water-proofing quality of the materials may be destroyed. This can be restored by an application of paraffine. Dissolve the paraffine with gasoline and apply with a clean brush, the gasoline will carry the paraffine into the fabric and will evaporate, leaving the paraffine in the fabric.

USEFUL HINTS. At A, Fig. 251, is shown a simple tool found to be universally useful for wedging off magneto driving pinions, and other small members fitted to coned shaft ends, with or without key retention. This can be easily made from a large file, or any piece of steel of sufficient dimensions, depending upon the work to which it would be applied. The opening in the fork need not be more than three-quarters inch for the average magneto, the tines about two inches long, and three-eighths inch wide and taper from nothing to about one-quarter inch at the thickest part. Two of these are needed and are placed back of the gear, the tapered portion of one piece resting on that of the other, as shown. To remove the gear the ends are driven in toward the centre at the same time. This exerts a lifting effort, due to the wedge action of the tools immediately back of the pinion. The advantage of this method is that the shaft on which the gear is mounted is not subjected to any side strains, such as would result if attempts were made to drive off the gear by holding an S wrench back of the gear and driving against it with a hammer. When removing worn sprockets from the counter shaft in order to replace them with new ones, trouble may be experienced in loosening the nut especially if the rear wheels have been removed. In such cases the chain may be utilized to hold the sprocket in the manner shown at B, Fig. 251, by anchoring it to the axle with an S hook made of three-eighths inch cold rolled steel rod The sprocket will be firmly held and the nut removed without difficulty.

Although some grades of rubber hose are better than others, unless properly cared for even the best will deteriorate rapidly. Among the factors which make for rapid wear are careless stowage and abuse. The hose is left on the wash stand, cars are run over it, and when it has served its purpose, it is thrown in a heap and oil and grease accumulations soon work havoc with the rubber walls. A good rule to follow is to have a place for everything and everything in its place. It is not unusual to see a coil of hose carefully hung upon a nail, as shown at C, each coil having a sharp "kink" in it, both top and bottom, as indicated. This sharp bend tends to break the fabric walls, and the hose soon leaks. The proper way of hanging a hose is to use five or six wooden pegs arranged around an arc of a circle, as shown. Under these conditions the coils take a gradual curve, and do not assume a sharp angle as when but a single point of support is utilized. If the hose is one of some length a reel should be used.

Often when fitting bushings and parts, and in general operations where reamers are used it is found that the tool will be just a trifle undersize, or that it is desirable to have the reamed hole just a little oversize. In such cases a simple expedient, as shown at D, Fig 251, will be found valuable. A small sheet of brass, or zinc is rolled in such a manner that it will fit between two of the cutting edges of the reamer. If the reamer is inserted with the roll of metal in place it will be evident that the reamer will be forced a trifle from the centre of the bore and the cutting edges of the reamer opposite the inserted metal roll will remove the metal. Very fine cuts should be taken, and the metal roll placed between different cutting teeth each time that the tool is used. In tapping out nuts it is often desirable to have the thread a little deeper than the standard, or to have the nut a loose fit on the bolt, as is sometimes necsesary when trying to place a machine screw nut on a carriage bolt. In this case a similar roll of metal may be placed between the cutting edges of the tap, as shown at E, Fig. 251.

Solder. Silver solders are generally used for very fine work. They are very fusible, and non-corrosive. Hard spelter is used for steel and iron work, and soft spelter for brass work.

When copper is soldered to iron or zinc, resin should be used, or if chloride of zinc is used for a flux, the joint should be washed afterwards to remove the acid. Un-annealed wires should be soldered at as low a temperature as possible. Solder is always an alloy of other metals. It must not only be more fusible than the metal, or metals to be joined, but it must have some chemical affinity for them. Different kinds of solder are therefore employed for different purposes. It is called either hard or soft, according to its fusing point.

Solders and spelters for use with different metals, and their proportional parts by weight are

Solder for:

Electrician's use—1—Tin, 1—Lead.

Gold—24—Gold, 2—Silver, 1—Copper.

Patinum—1—Copper, 3—Silver.

Plumber's—Hard—1—Lead, 2—Tin. Soft—3—Lead, 1—Tin.

Silver—Hard—1—Copper, 4—Silver. Soft—1—Brass, 2—Silver.

Tin—Hard—2—Tin, 1—Lead. Soft—1—Tin, 1—Lead.

Spelter for:

Fine brass work—8—Copper, 8—Zinc, 1—Silver.

Common brass—1—Copper, 1—Zinc.

Cast iron—4—Copper, 3—Zinc.

Steel—3—Copper, 1—Zinc.

Wrought iron—2—Copper, 1—Zinc.

FLUXES FOR SOLDERING. Some good fluxes for soldering purposes are:

Iron or steel............	Borax or sal-ammoniac.
Tinned iron	Resin or chloride of zinc.
Copper to iron	Resin.
Iron to zinc	Chloride of zinc.*
Galvanized iron	Mutton tallow or resin.
Copper or brass	Sal-ammoniac or chloride of zinc.
Lead	Mutton tallow.
Block tin	Resin or sweet oil.

*Chloride of zinc is simply zinc dissolved in hydrochloric (muriatic) acid, until the acid is cut or killed.

Scratched Cylinder. The cylinder may be temporarily fixed by taking it to a first-class tinsmith and having the scratches filled with silver solder. The soldered places must be then carefully scraped flush with the bore of the cylinder. The best way is to have the cylinder rebored and the piston-rings re-turned.

If the scratches are not too deep the cylinder can be rebored, and a new set of piston-rings made to fit the new bore. The limit to such an increase in bore is about one-sixteenth of an inch.

If the damage to the cylinder walls has been comparatively slight, due to the conditions being recognized early, the engine should be disassembled and the surfaces thoroughly cleaned of any dirt or carbon. After reassembling, the full amount of lubricating oil should be put into the engine, and with the oil should be mixed an amount of graphite, in either the amphorous or flake form, proportioned to the kind being used and the body of the oil. Continued use of graphite will tend to fill the small scratches in the metal.

Garage—Cleaning Floors. A hot saturated solution of common washing soda will do very well. This can be made up in quantities and stored against future use. If this method is used, be sure to reheat it before using, the boiling point being about right. Since that will be too hot to apply with the hands, use any old broom or brush to "slosh" it around on the floor. An equally good, if not better, solution to use for this purpose is trisulphate of sodium, marketed by several chemical companies, and sold at from four to five cents per pound at retail. This can be used cold and will not injure the most delicate hands; on the other hand, it will clean them very thoroughly, so that users of this solution use it for the hands as well as for the floors. This is strong, however, and may be used to remove paint.

PROTECTION FROM FIRE. The recommendations of the National Fire Protection Association pertaining to garages and their operation are as follows: No dynamo or gas engine should be permitted where gasoline is stored or handled; all exposed lights should be eliminated; cleaning of acetylene lamps and removal or renewing of carbide should be carried on outside of garage; the residue of acetylene lamps should never be cast on the floor; machines should have oil tanks emptied before being put in the repair shop; the use of extension electric wires is condemned, as they may cause fire; motor testing should be done outside, for sparks might ignite the fumes of gasoline; storage tanks should be filled from outside of garage; all volatile oils should be stored in good, heavy tanks under ground, as far away from the building as possible; pipes for filling storage tanks should not pass through the garage in any way; a filling station should be twenty to thirty feet from the entrance to the garage, and tanks of cars filled from there if it is necessary to fill them when the cars are inside of the garage; furthermore, the station should be fireproof, and all cars should be brought to this point for filling; smoking and carrying of matches, or use thereof should be strictly prohibited; floors should be kept free of oil drippings, and pails of sand should be kept handy in proximity to gasoline.

A garage of ordinary size should be equipped with at least four or five chemical fire extinguishers, and these should be placed so that they may be quickly reached by any one in case of emergency. The stream from such an extinguisher will smother a fire before it has done much damage if the flame can be reached within a minute or so of the time when it started. The chemicals usually used will not harm the finish of the car if the surfaces exposed are immediately washed in the usual way. Slight marring is of course preferable to destruction.

Rheostat. A rheostat is a device for regulating the flow of current in a closed electrical circuit, by introducing a series of graduated resistances into the circuit.

Running Gear. A complete running gear includes the frame, springs, wheels, motor, speed-change-gear, axles and the machinery of the car except the body. The French word, chassis, is sometimes used to designate a running gear,

Secondary Current. The current which takes its rise in the fine wire of the induction coil, and which flows through the wire to the spark plug, is induced in the fine wire by the sudden reversal of the magnetism of the iron core.

This change of magnetism is caused by the sudden interruption of the primary current.

Self-firing, Causes of. If the motor should continue to run after the switch has been opened, it is due to an insufficient supply of lubricating oil, causing the motor to overheat, or to the presence of soot or some projection in the combustion chamber becoming incandescent. It may also be due to lack of water or to the water circulation working poorly, causing the motor to overheat.

Shaft Drive. The principal advantages which may be advanced for the shaft drive are, absence of noise, convenience with which all the parts may be housed in oil and protection from dust. It is especially adapted for use upon cars carrying their engines in front, with the crankshafts parallel with the length of the car, as the direction of the power shaft does not have to be changed until the rear axle is reached, and as the power must also pass through one set of bevel gears, it is more efficient.

The principal disadvantages of the shaft drive are that it is difficult to repair; it is somewhat more complicated; it has considerable end-thrust and it is claimed that it is harder on the tires.

Soldering. The surfaces to be joined should be fitted to each other as accurately as possible and then thoroughly cleaned with a file, emery cloth or wire brush. The work should then be heated as hot as possible without danger of melting, as this heating causes the solder to flow and secure a good hold on the surfaces. It is important that the soldering iron be kept well heated during the work, otherwise the solder will only stick and will not join the surfaces.

The end of the soldering copper should be well tinned by first cleaning it with a file or emery cloth while hot, then dipping into flux and rubbing the tip on a bar of solder until a space extending one-half inch back is covered with clean bright solder. The tinned end should not be placed directly in the heating flame.

Sweating is a form of soldering in which the surfaces to be joined are first covered with a thin layer of solder. These surfaces are then placed in contact and heated to a point at which the solder melts and joins. Sweating makes a stronger joint than ordinary soldering.

Spark Plugs. The trouble with motors misfiring, is generally due to dirty spark plugs. This is caused by using too much cylinder oil, which, when subjected to the intense heat in the cylinder, turns to carbon. This carbon deposits on the insulated porcelain and the body of the plug, and instead of the current jumping from the point in the body to the point in the porcelain and making a spark, it follows the easiest path, which is the carbon, and does not make a spark at the plug points at all. When this occurs the motor will misfire. The first thing to do when a motor misfires is to test the spark plug. Turn the motor until the battery circuit is closed. Unscrew the spark plug from the motor, then reconnect the wire to it just the same as it was before. Lay the metal part of the plug body on the flywheel or some other un-

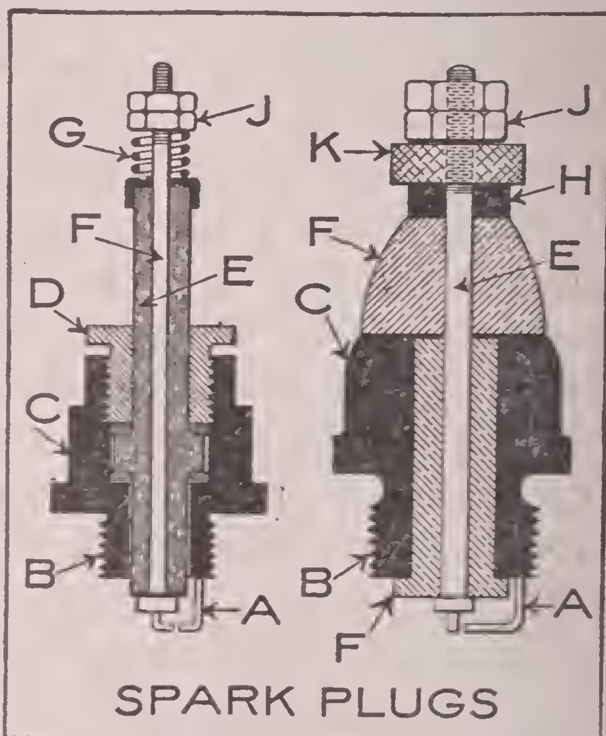


Fig. 252

A—Platinum point.
B—Thread.
C—Plug body.
D—Bushing.
E—Insulated terminal.
F—Porcelain bushing.
G—Expansion spring.
H—Asbestos washer.
J—Lock nuts.
K—Assembly nut.

painted part of the motor, being careful that the metal part of the plug body only touches the motor and that the porcelain part is clear. If the spark jumps in short jerks between the inner end of the porcelain and the interior of the plug body it is sooted, and needs cleaning.

If it jumps at the points as it should do, the trouble is elsewhere; probably at the battery, loose connecting wires, or the vibrator of the coil is not properly adjusted.

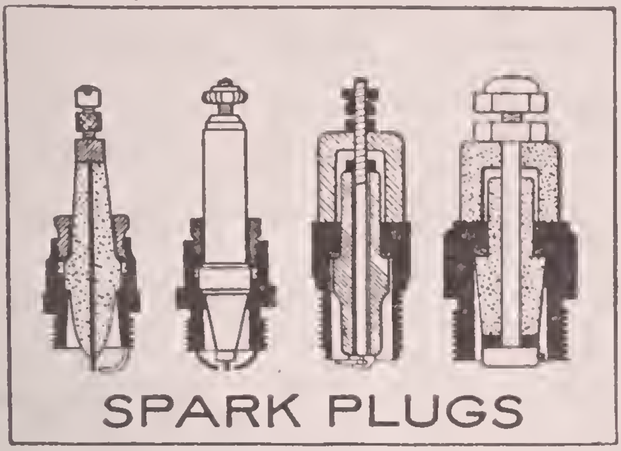


Fig. 253

To clean a spark plug properly use a 50 per cent solution of hydrochloric (muriatic) acid, washing the points of the plug with a tooth brush, occasionally dipping the plug into the

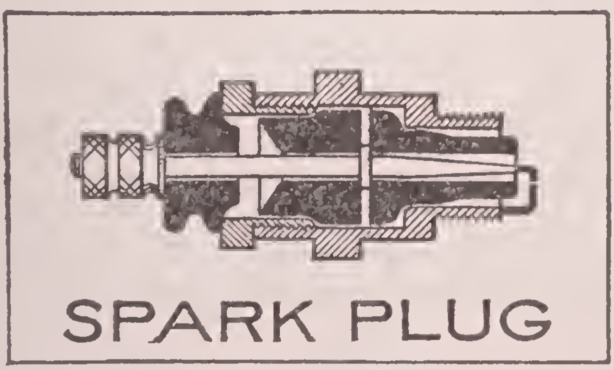


Fig. 254

acid. After cleaning the spark plug in this manner, rinse it in water.

Spark Plugs—Construction of. Two spark plugs are shown in Figure 252, which, while differing radically in their construction, effect the same purpose, that of producing a spark or arc in the combustion chamber of the motor. The accompanying table and reference to Figure 252, will fully explain the construction of the spark plugs.

Cross-sections of four different forms of spark plugs are shown in Figure 253. All are constructed with a view to make the outside or extraneous path caused by sooting, as long as

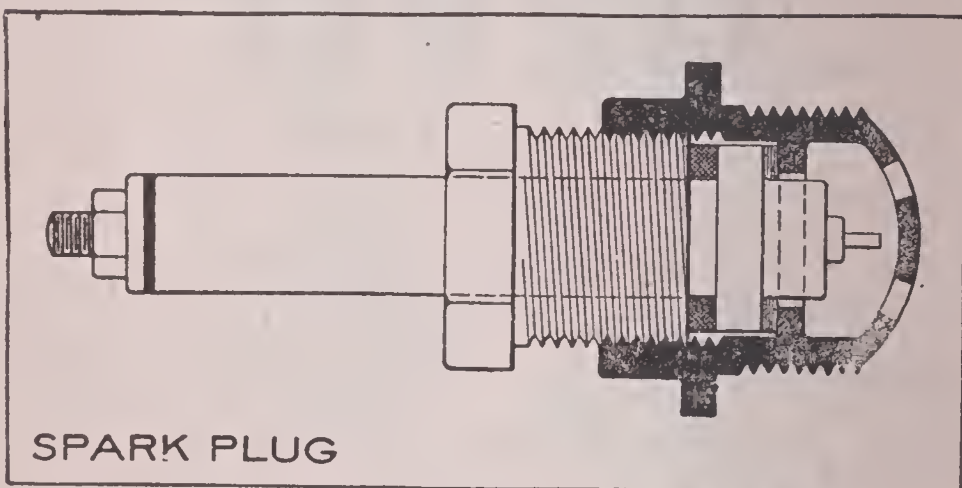


Fig. 255

possible, so as to prevent if possible short-circuiting of the plug from this cause.

Figure 254 shows a form of spark plug in which two extra air-spaces are provided, one between the center rod or terminal and the porcelain bushing and the other between the porcelain bushing and the shell or body of the plug.

The spark plug shown in Figure 255 has a closed chamber around, and over the center insulated rod or terminal; this chamber is a part of the body of the plug and forms the other terminal of the plug. It acts as a small combustion chamber, and streams of fire are supposed to be thrown from the small openings in the chamber, when the arc or spark occurs therein.

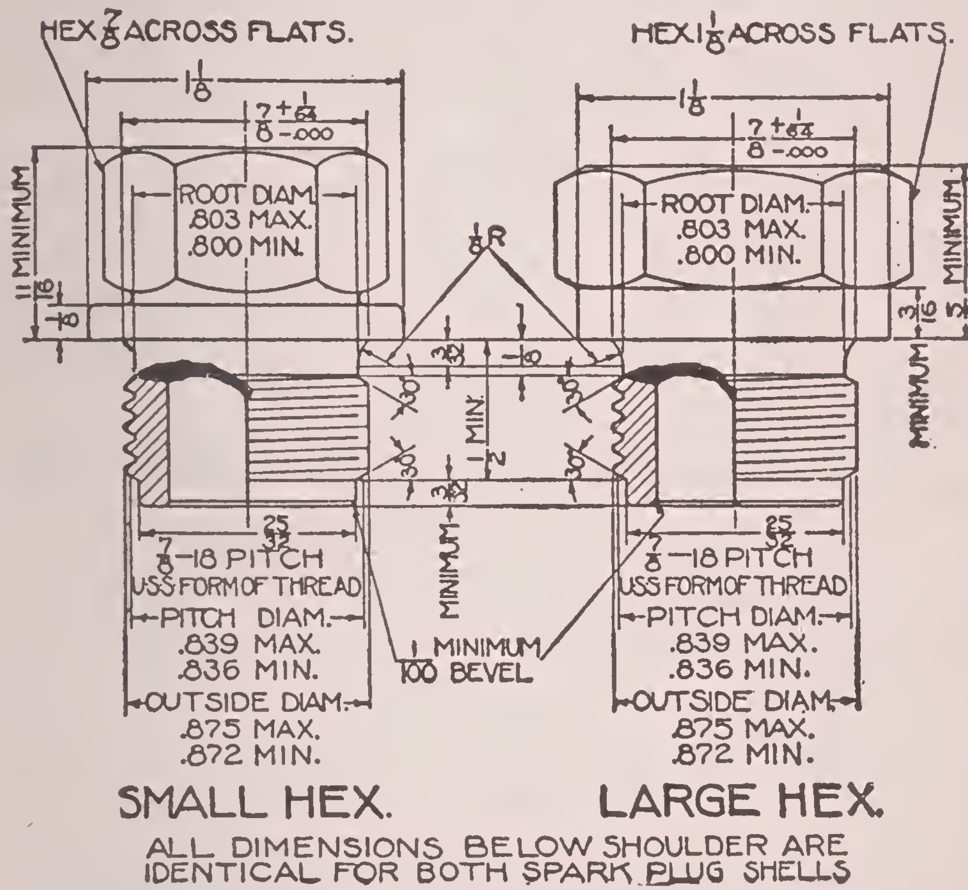


Fig. 256
S. A. E. Standard Spark Plug

Spark plugs of American manufacture are made with three different sizes of threads: One-half inch pipe-size, the actual outside diameter of which is .84 of an inch, with 14 threads per inch. Seven-eighths of an inch diameter, with 18 threads per inch, and .7 of an inch diameter, with 17 threads per inch. The last named one is the French, or Metric standard thread.

Specific Gravity. In the absence of a proper instrument, the specific gravity of gasoline or any other liquid may be obtained as follows:

Weigh a certain quantity of distilled water at 4 degrees Centigrade, or 39 1/3 degrees Fahrenheit.

Weigh the same quantity of gasoline or other liquid under test.

Divide the weight of the liquid by the weight of the water, and this will give the required specific gravity of the liquid.

The specific gravities of various liquids are as follows:

Alcohol at 15° C.	0.794
Acid, nitric	1.217
Acid, sulphuric	1.841
Ether at 15° C.	0.720
Naptha	0.848
Oil, linseed	0.94
Petroleum	0.878
Gasoline at 15° C.	0.680 to 0.720
Water, sea, at 4°	1.026
Water, pure, at 4°	1.0

The specific gravity of the electrolyte used in storage batteries is usually close to 1,250 under ordinary conditions. This figure will reach 1.300 or 1.310 with a fully charged starting and lighting battery, and may fall as low as 1.100 with a battery that needs charging badly.

The specific gravity of a storage battery should be tested while the battery is being charged or immediately after the charge has been discontinued, never just after water has been added.

To test the gravity, it is necessary to use a hydrometer made and graduated for this work, the instrument being preferably enclosed in a tube fitted with a bulb and nozzle and called a hydrometer syringe. With the filling caps removed from each cell of the battery, the bulb is compressed, the nozzle inserted into the cell and enough liquid drawn up to float the hydrometer. The marking on the hydrometer stem at which the surface of the liquid remains is the specific gravity of that cell. The gravity should be nearly the same in all cells with a good battery. The liquid should be returned to the cell from which it was drawn.

Springs. The length and number of leaves in the springs of motor cars of similar weight and power vary, and without any reason for so doing. The general use of pneumatic tires hides many imperfections in this respect as well as in others. Springs of insufficient strength are a source of great danger, and frequent examination should be given to them. Springs are not necessarily of insufficient strength because they appear to be light. Short springs are not desirable, as they are more liable to break than a longer spring, the deflection per unit of length being greater. Stiffness in short springs is usually avoided by lightness, which is likely to lead to breakage, especially when the hole

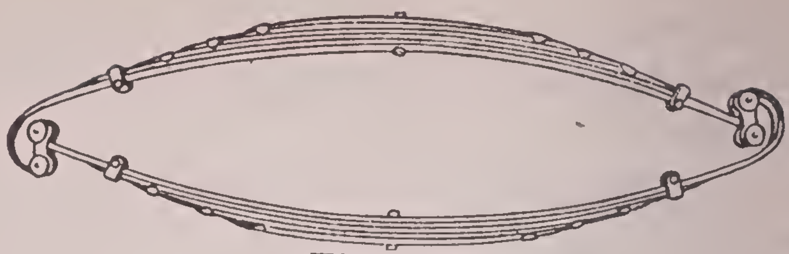


Fig. 257
Full Elliptic Spring, Scroll Ends

Fig. 258
Semi or Half-Elliptic Spring

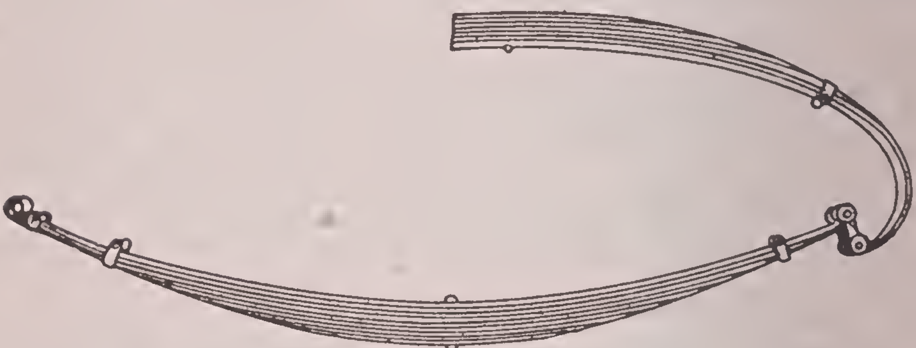


Fig. 259
Three Quarter Elliptic Spring

Fig. 260
Fixed Cantilever Spring

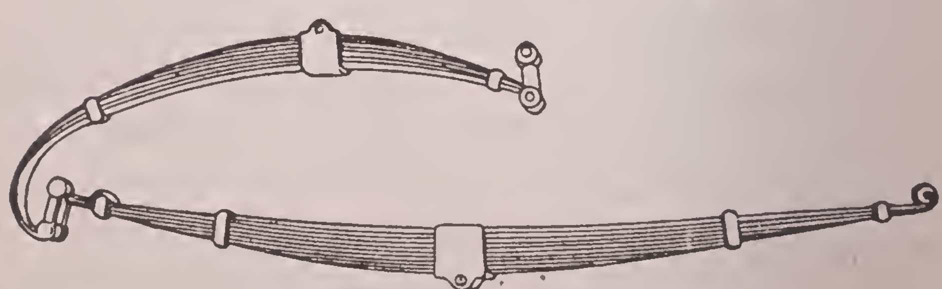


Fig. 261
Three Quarter Floating Cantilever Spring

for the bolt through the center of the spring is made larger than necessary.

SPRINGS—DIMENSIONS OF. In calculating the dimensions and elastic limit of springs for motor-car use, the elastic limit must be carefully considered with regard to the dead, and maximum loads to be carried by the car. The dead load is the weight of the car when at rest. The maximum load is the greatest weight that can possibly be carried with good spring action. The springs to retain their elasticity should have their ultimate strength far beyond their maximum load capacity.

The old practice of fixing a uniform curvature of the spring leaves frequently leads to breakages due to distortions set up at the spring perch. This tendency is now aborted by making the spring leaves in such a way that the curvature begins at points beyond the spring perch, so that the clamps when they are pulled into tight relation do not straighten out the plates. It is still the custom to use a leather pad on which to rest the springs, because thereby the coefficient of friction becomes that of leather, and creeping tendencies are as a consequence remote. There is also the question of the camber given to the respective spring plates. If the plates are all of the same thickness, they should all be curved to the same radius, for then the extreme fiber strain would be equal in all the plates for every alteration in camber incidental to the service they are placed to perform.

Springs—Testing and Material. The life of a spring is forecast by the maker thereof, almost independently of the quality of the material. If the spring is limber, and it is so placed as to indicate spring play, just at the point of reversals of camber, the life will be shortened. The superior grades of materials will stand this abuse for a comparatively long time, but the dynamic life of steel, like the life of every other animated thing, is limited. Inferior materials, advantageously situated, might last far longer than the superior products working at a disadvantage. The initial camber to give a spring, for a given static camber, is a problem for the springmaker.

Fig. 262 shows three views of a given spring, under the conditions as follows: The spring under static load, indicating the static camber; straightened out under load; in reverse camber, in a testing machine, to the limit before permanent set.

It is worth while to study these three conditions in relation to springs, because they have to do with the life of the spring in service, and the easy riding qualities of the car due to spring action. It might be said in general that the greater the difference between the initial and the static camber, the more pronounced will be the easy riding qualities, and it might be said as well that the greater the initial camber, and the greater the possible reverse camber, the better will be the life of the springs, especially if we take into account that the spring action in service will be limited between the two points, as represented by the initial camber on the one hand and the condition, which means that the spring leaves will no more than straighten out in actual service. If the service conditions are such as to eliminate any reversal of camber,

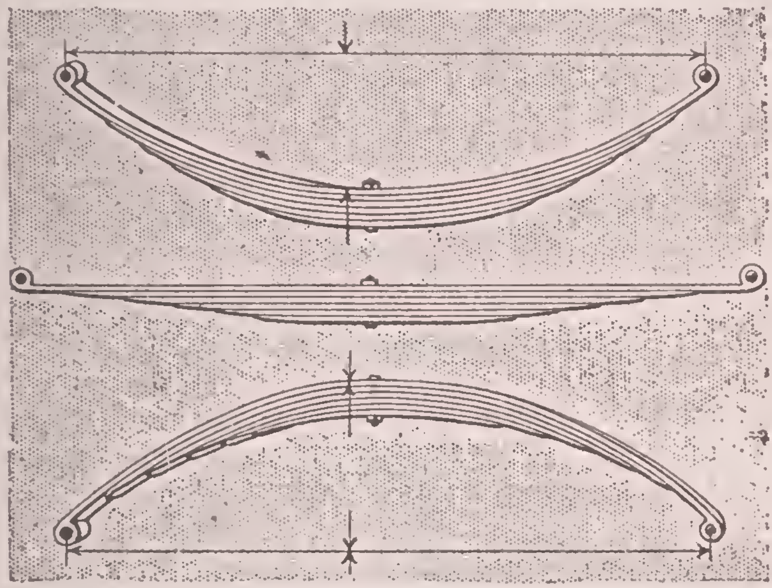


Fig. 262

then it may be said the factor of safety will be represented by the amount of the reverse camber in a testing machine before permanent set.

SPRINGS—CARE OF. Springs should be examined occasionally, and while often overlooked, this seemingly trifling matter has a direct bearing upon the smooth, easy running of the car. Owing to the fact that the springs are exposed to the weather, rust is very likely to occur at this point, and to this unsuspected corrosion is often due the occasional "squeak." Although many cars are provided with some means for lubricating the friction surfaces, many cars are not so well provided for and when rust makes its appearance along the joints there is a crying need for oil. This may be conveniently applied by placing the jack between spring and frame, and slightly opening the leaves or plates. The toggles and links should also have a little oil occasionally and when about this work it is well to examine the nuts of the clips. These nuts are prone to work loose.

TABLE 13

SPRING WIDTH, EYE AND CLIP DIAMETER

(S. A. E. Pleasure Car Standard)

Car Weight	Spring	Load per Spring	Spring Width	Eye Diam.	Clip Diam.
1,800 to 2,600	Front	500- 700	1¾	⅝	1/2
	Rear	600- 750	1¾	⅝	1/2
2,600 to 3,200	Front	600- 800	2	⅝	9/16
	Rear	700- 900	2	⅝	9/16
3,200 to 4,000	Front	750-1,000	2¼	⅝	5/8
	Rear	850-1,100	2¼	⅝	5/8
Over 4,000	Front	Over 1,000	2½	¾	3/4
	Rear	Over 1,100	2½	¾	3/4

Car weights are for cars empty, while loads per spring are for total loads of cars with passenger and equipment.

Where rear springs take the drive or both drive and torque, ⅛ inch is added to the diameter of the eye at the driving end. Where rear springs take the drive, the drive and torque or are underslung, 1/16 inch is added to the clip diameter.

In Figure 263 are shown a number of forms for the leaf points used on springs. The five in the upper row and the two at the left of the lower row are the types most used. Reading

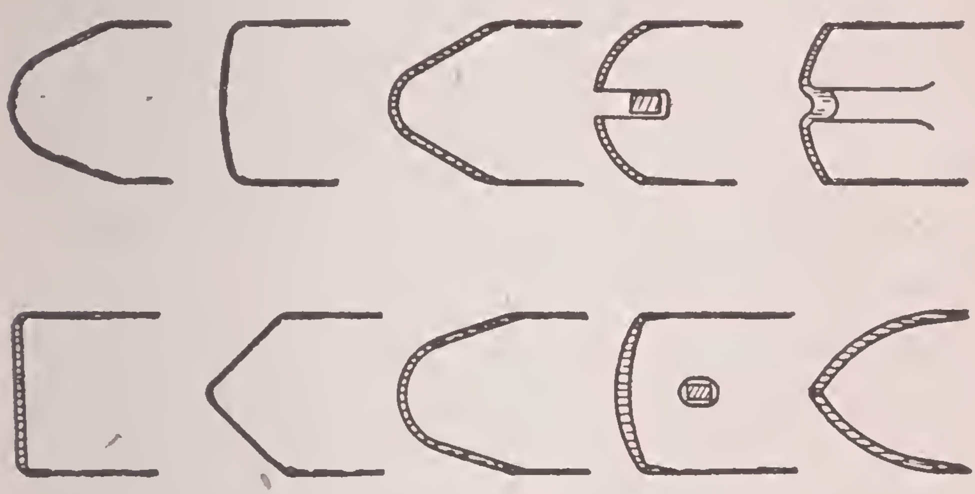


Fig. 263
S. A. E. Standard Spring Leaf Ends

from left to right in the upper row, the points are named as follows: oval, round point, short French point, round end slot and bead, and ribbed. In the lower row, from left to right the names are: square point tapered, diamond point, egg shape and bevel, blunt end slot and bead, and French point.

Starting and Lighting Systems.

Four principal types of engine starters have been used; the air starter, the mechanical starter, the acetylene starter and the electric starter. Beginning with the production of 1916 cars, the electric starter is the only one found as standard equipment.

Acetylene starters were used by many cars in 1913. This form admits acetylene gas from the lighting tank to the cylinder that is ready to fire through a distributor valve. The passage of an ignition spark caused by operating a button on the dash fires the gas and the force of the explosion starts the engine.

Mechanical starters are found in many forms. They consist of a mechanism through which the driver is enabled to turn the engine crankshaft through connections that lead to a handle or lever that may be reached from the seat.

Compressed Air Starters. In a typical air-pressure system the motor is operated with compressed air until regular explosions take place in the cylinders; the air supply is then shut off and the motor takes up its regular operations.

The parts of this self-starter are as follows (see Fig. 264): 1, a high-pressure, four-cylinder air pump, for compressing air in a storage tank; 2, a pipe for carrying air from pump to storage tank; 3, a pipe which carries air from

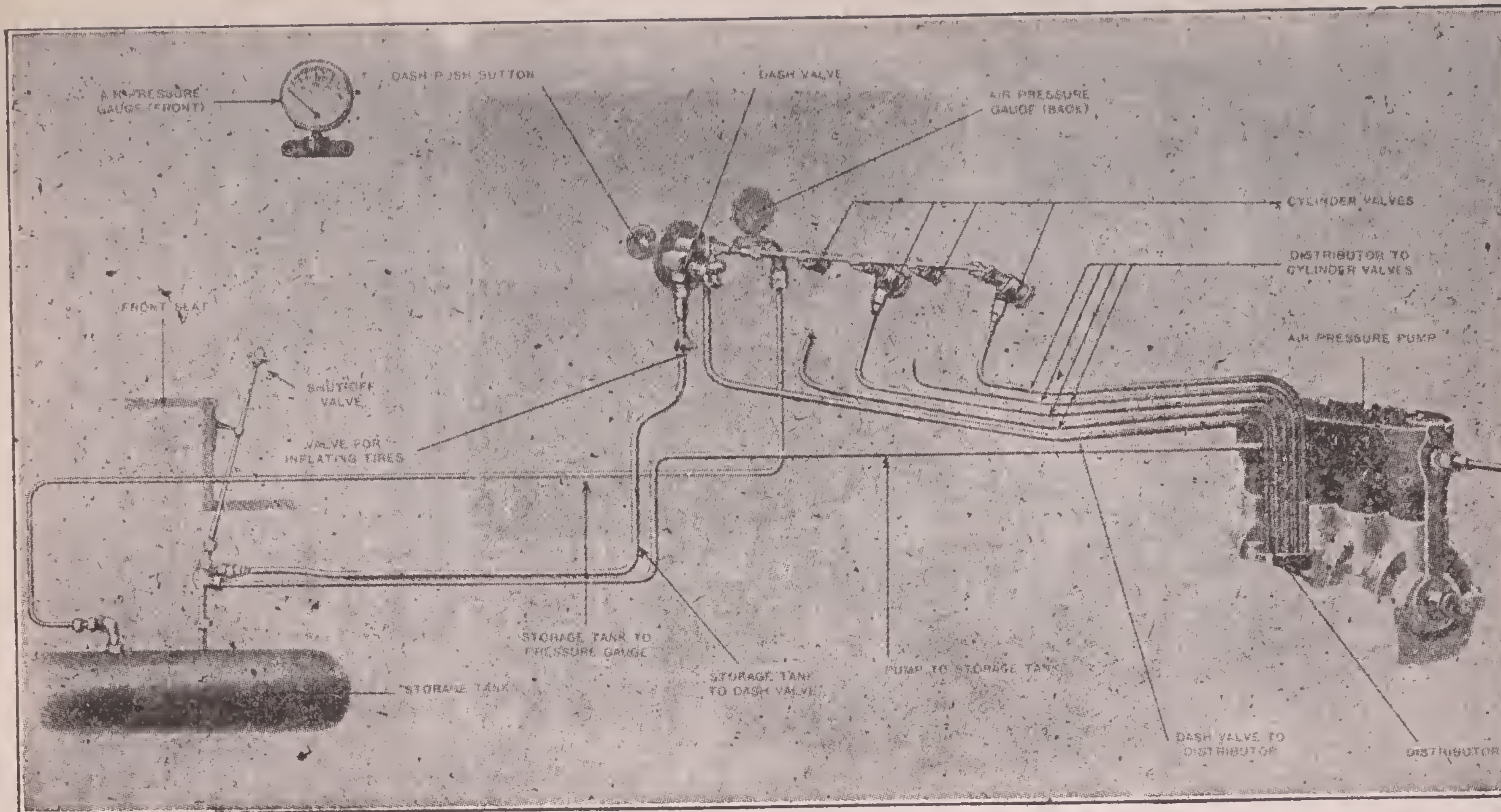


Fig. 264—Chalmers Air Pressure Starting Mechanism.

tank to push valve on the dash; 4, a pipe which carries compressed air from the push valve to the "distributor"; 5, pipes through which air is carried from the distributor to the various cylinders; 6, poppet valves—one in each of the cylinders—by means of which compressed air from the distributor is admitted to the cylinder ready for the working stroke; 7, a pressure gauge on the dash, which keeps the operator informed of the amount of compressed air in the storage tank; and 8, a pump clutch, operated by a foot pedal, which throws the gears of the air pump into mesh.

The air pump in this system is driven by a silent drive chain from the water pump shaft, and operates only when the gears are thrown into mesh by pressing the pump clutch foot pedal. It is a simple device for compressing the air and delivers a steady flow to the storage tank. A pressure of 50 lbs. in the tank will start the motor under ordinary conditions, but it is advisable to keep the pressure at about 150 lbs.

The storage tank is carried beneath the body of the car and is tested for a pressure of 600 lbs. to the square inch.

The dash push valve opens the air line from the storage tank to the distributor and simultaneously opens the cylinder valves so that air coming from the distributor through the pipes shown in Fig. 264 has ready access to the cylinders. When the foot is removed from the dash button, both the escapement valve and the cylinder valves are closed automatically and the compressed-air starter is shut off from the motor.

The distributor sends charges of compressed air into the cylinders ready for the working stroke, in their order of firing. It is geared to the pump and magneto shaft and positively timed for feeding air.

This type of self-starter is also used for the purpose of inflating tires by means of a special shut-off valve and hose.

The principle of compressed-air starters is to admit air under 50 to 150 lbs. pressure from a generous reservoir directly to the motor cylinders at the beginning of each expansion stroke. This operates the motor without affecting the mixture in the cylinders. When running under air pressure the admission of the compressed air at almost the moment of the spark operates the same as an ignition, causing a rise of pressure in the cylinder. After it has performed its work this pressure is released by the exhaust valve in the same manner as the burned gases are released when the motor is running under its own power.

Allis-Chalmers Equipment. The most commonly used type of Allis-Chalmers equipment makes use of a combined motor-dynamo, Fig.

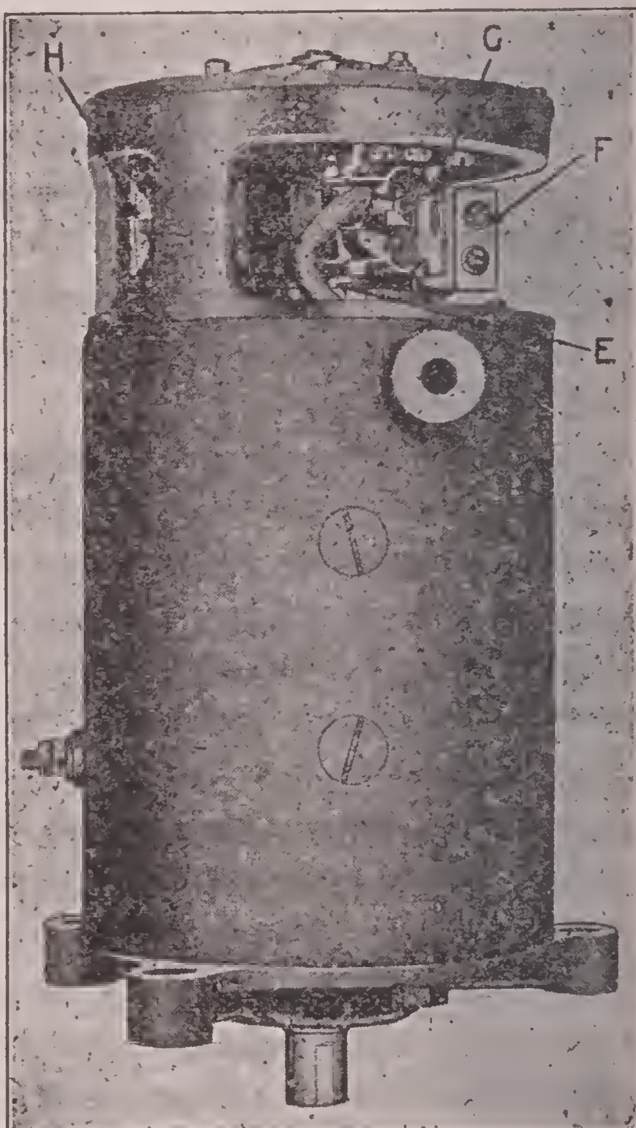


Fig. 265
Allis-Chalmers Motor-Dynamo. E, Commutator. F, Brush Holder. G, Brush Connection. H, Brush Connection.

265, operating at six volts pressure for starting, charging and lighting. In addition to the motor-dynamo, the system includes the battery, a starting switch and a separately mounted combined cut-out and regulator.

Pushing the starting switch connects the battery with the motor-dynamo, which then operates as a motor to crank the engine to which it is mechanically connected. The switch is then released after the engine fires. The motor-dynamo speeds up with the engine and, when it reaches a certain predetermined speed, is automatically connected to the battery and the lighting system by means of the cut-out. If the lights are burning, part of the current is used in lighting, the surplus going to charge the battery. When the engine slows down below the charging speed, the cut-out opens the circuit between the generator and battery.

By removing the cover band, the commutator may be examined. When in good condition it will show a glaze and will be dark brown in color. If the commutator appears dirty or greasy it should be wiped off with a clean cloth free from lint, slightly moistened with oil.

Do not disturb the brushes so long as the motor-generator appears to be operating properly. They should make good contact with the commutator and slide smoothly in the brush holders.

The purpose of the combined cut-out and regulator is to connect the generator to the battery when its voltage equals that of the battery, and to maintain a practically constant charging current with the widely varying speeds of the engine. It also disconnects the battery when the motor-generator voltage falls below that of the battery, preventing the battery from discharging.

The regulator-cutout consists of a compound wound electromagnet with two armatures, one of which serves as the cut-out while the other regulates the charging current. The shunt regulator winding is always connected across the generator terminals. When the generator voltage is sufficient for charging, the electromagnet attracts the armature, closing the circuit through the series coil of the regulator of the battery. The current flowing in the series coil then assists the shunt coil to hold the contacts together. With an increase in generator speed, the charging current will increase, strengthening the regulator electromagnet. At a certain critical point the second armature will vibrate, alternately cutting a resistance in and out of the generator field circuit, which will reduce the charging current by lowering the generated voltage. When the generator speed, and consequently the voltage, drops below charging value the reverse battery current flowing in the series winding neutralizes the shunt winding, releasing the armature and thus opening the circuit before the battery can discharge.

The internal connections and mechanism of the regulator-cutout are shown in the diagram, Fig. 266.

The regulator is provided with a fuse to pro-

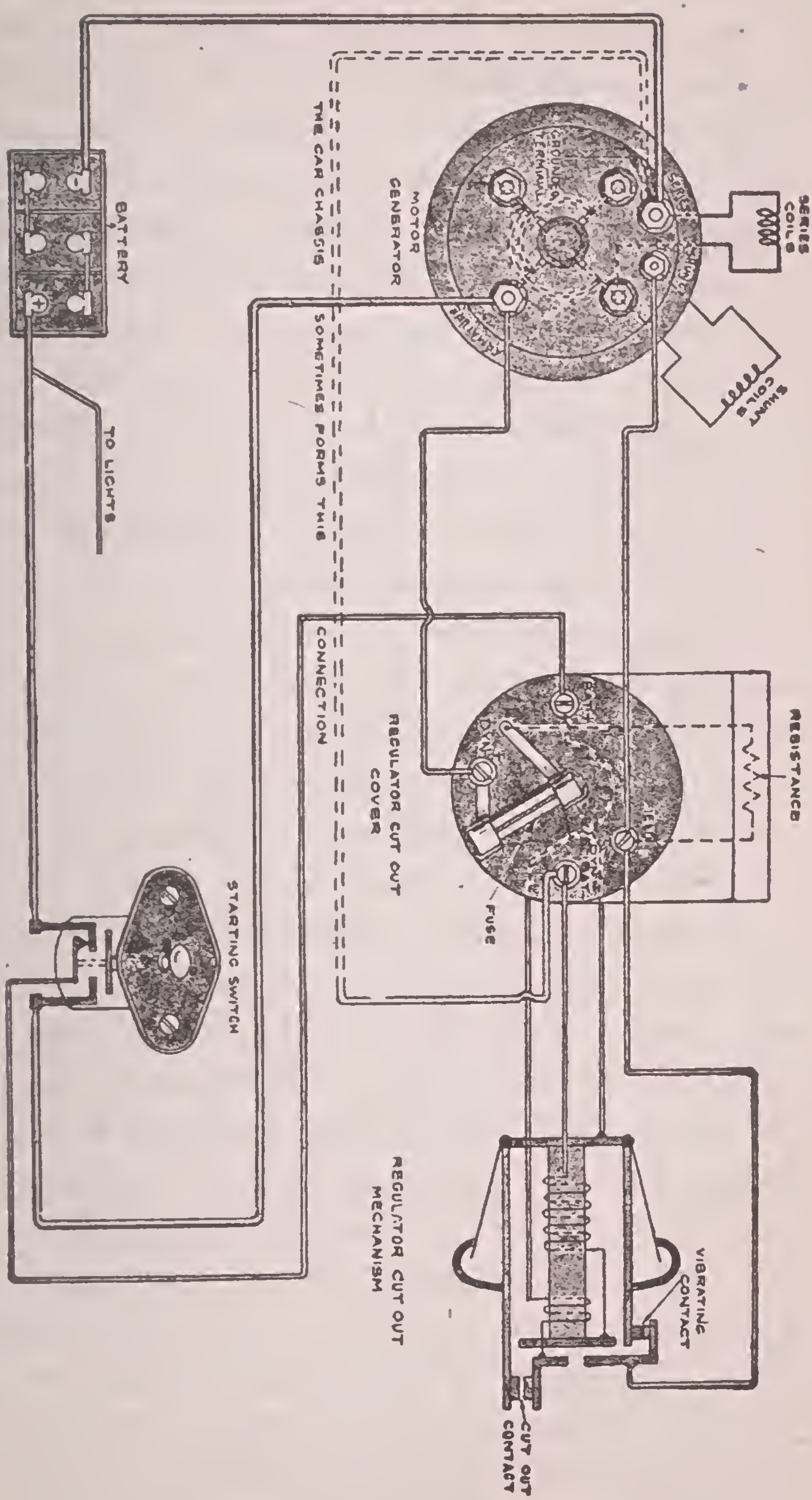


Fig. 266
Allis-Chalmers Motor-Dynamo Internal Connections

tect the system from excessive charging current, or an improper discharge through the starter, in case the regulator should not function properly. This fuse has a capacity of 45 amperes and carries the shunt field current as well as the battery charging current. The fuse, which is made of an especially hard alloy to withstand the high temperature near the engine, should always be replaced by one of the same make. If several fuses are blown within a short time, the regulator is probably out of order and should be replaced. This fuse does not protect the lighting and horn circuits.

To prove whether the motor-dynamo is charging the battery or not, remove the wire from the "BAT.+" terminal of the regulator and insert an ammeter between this terminal and the wire, with the positive terminal of the meter connected to the terminal of the regulator. With the engine running at about 60 revolutions per minute or higher, the meter should show a charging current of 10 to 18 amperes. If the meter shows no current, the motor-dynamo is either not developing any voltage or there is an open circuit in the charging line. To determine whether the motor-dynamo is developing any voltage, open the circuit at ammeter and then remove the wire from the "F L D" terminal of the regulator. With the engine still running as above, there should be quite a flash on removing the wire from the "F L D" terminal of the regulator. All these tests are to be made with a good fuse in place on the regulator. If no flash is obtained on removing the wire from the "F L D" terminal, hold the wire on the fuse clip for a few seconds and note whether there is a flash on removing it. A flash here and none from the "F L D" terminal indicates a fault in the regulator. No flash from the fuse clip indicates a fault in the motor-generator. It is assumed here that the connections between the regulator and the motor-dynamo have been examined and found correct and sound.

If the motor-dynamo develops its voltage but still does not charge the battery, the fault is either in the regulator or the auxiliary contact of the starting switch. This can be located by connecting up the ammeter again as before, and with the engine still running hold a wire pumper in the hands and first connect the "DYN+" terminal of the regulator to the "BAT+" terminal. If the battery now charges, the fault is in the regulator. If no result is obtained, connect "BAT+" terminal of the regulator to the positive terminal of the battery. The charging of the battery now would indicate that the fault was in the starting switch.

The motor-dynamo should not be run with the charging circuit open, except for a minute or two at a time in making tests and not at all at very high speeds, as it would damage both the motor-dynamo and the regulator, and also the lights if turned on. If it is necessary to operate the car with the battery removed or with the battery circuit open in any way, so that it cannot charge, the fuse must be removed from its place on the regulator.

Auto-Lite Equipment. These systems consist of separate unit dynamos and starting motors operating with a six-volt pressure in all

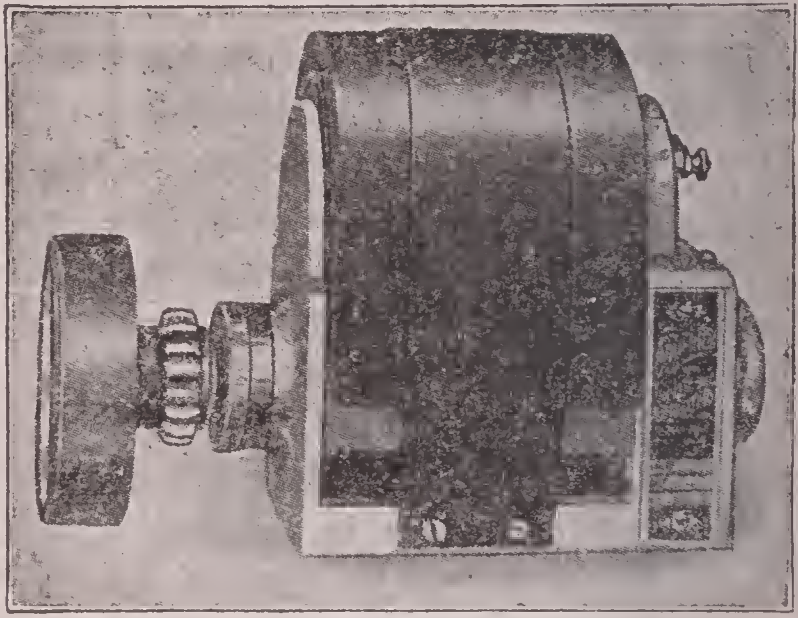


Fig. 267
Auto-Lite Dynamo With Permanent Field Magnets and Clutch Governor

cases. The first models were of the permanent magnet type, that is to say, the dynamo field consisted of six powerful steel magnets without the usual coils, Fig. 267. These magnets were of the inverted U, or horseshoe, type, and underneath the arch thus formed was mounted an electromagnetic cut-out which closes the charging circuit whenever the dynamo voltage is sufficiently high to charge the battery. This part of the mechanism may be exposed by removing the brush wires and taking out the plate that carries the positive and negative dynamo terminals.

This permanent magnet dynamo is driven from the engine by silent chain, but between the chain sprocket and the dynamo armature shaft is a form of slipping clutch governor contained in the drum seen at the left hand end of Fig. 267. The shell of this drum has its driving connection to the shaft by means of two shoes that are pressed outward by springs. Two weights are carried at or near the ends of corresponding arms inside of the drum, and when the armature shaft has reached a certain predetermined speed the centrifugal action of the weights overcomes the tension of the springs and the shoes release their hold on the shell. By thus preventing an armature speed above the desired maximum, the voltage and output of the dynamo is held at a point suitable for battery charging.

A later form of Auto-Lite dynamo is shown in Fig. 268. This model retains the inverted U form of field magnet cores, but around the top of the magnet arch is placed a field coil housing and in this housing is a shunt and a reversed series field winding. The shunt field winding is attached between the brushes in the usual way, and the entire dynamo output passes out through the reversed series winding. This series winding being placed in such a way that it opposes the action of the shunt, dynamo output above a certain point is made to overcome the field magnetism to such an extent that the amperage shows no further rise. The two dynamo terminals are seen on the front of the field housing and with this machine the electromagnetic cut-out is separately mounted, usually on the dash of the car.

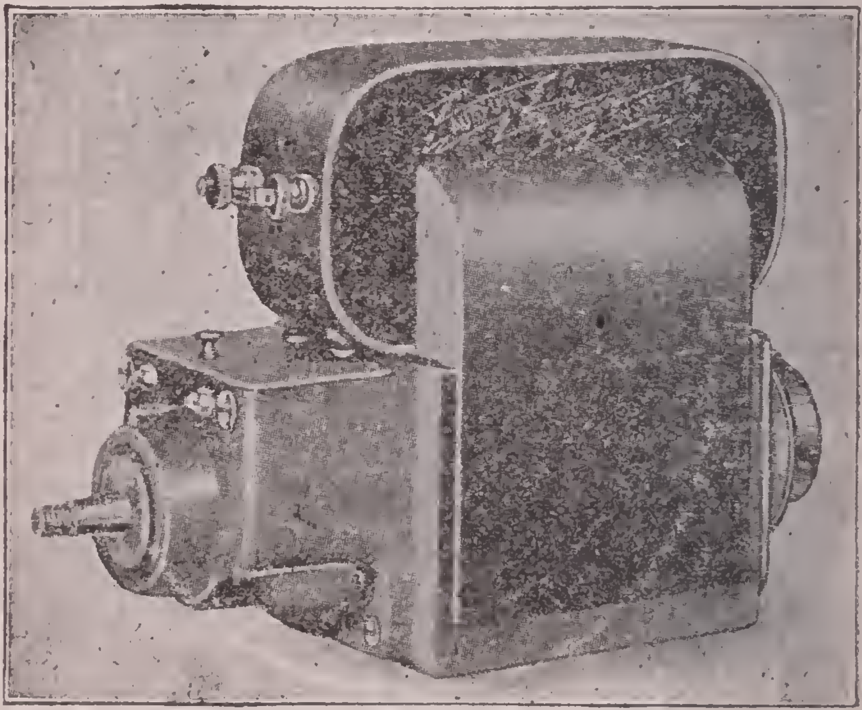


Fig. 268
Auto-Lite Dynamo With Electromagnetic Fields

A third type of Auto-Lite dynamo is shown in Fig. 269. This machine is fully enclosed and has its fields placed above and below the armature. The field windings and regulation of output by means of the reversed series coil is the same as in the type just described. The brushes and commutator may be exposed by removing the plate A.

Bijur Equipment. These systems are made in three distinct forms, two being six-volt separate unit dynamo and starting motor types, while the third is a combined motor-dynamo operating at twelve volts for both charging and starting.

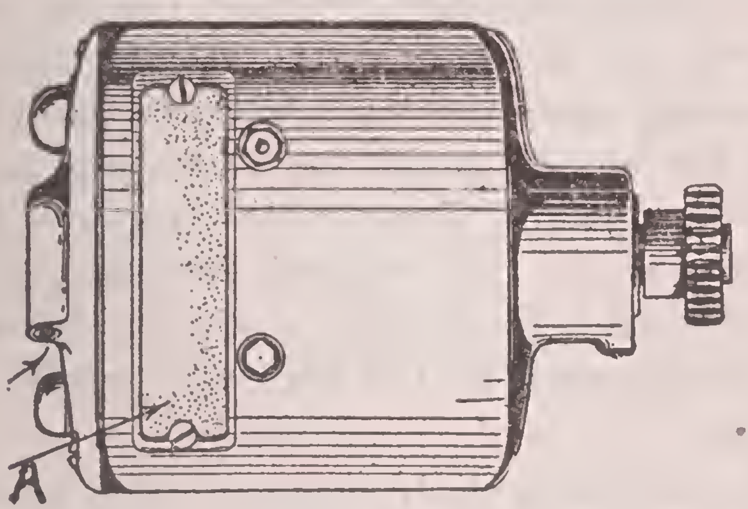


Fig. 269
Auto-Lite Fully Enclosed Dynamo.

One of the six-volt systems makes use of a straight shunt-wound dynamo having a combined regulator and cut-out mounted in an aluminum housing on top of the dynamo case. Connected in series with the shunt winding is a coil of high resistance wire which is automatically inserted in the shunt field circuit by the regulator, this action keeping the voltage constant. The regulator consists of an electromagnet with its winding shunted across the brushes, so that current always flows around the magnet when the dynamo runs, also the regulator contacts which are connected to carry the shunt field current around the resistance coil when they are closed. As the dynamo voltage rises, the magnet pulls the armature against the small spring and opens the contacts. The shunt field current then flows through the resistance and is so reduced that the field strength and voltage immediately fall. The low voltage reduces the strength of the electromagnet and the spring again closes the contacts, allowing the field current to avoid the resistance coil and raise the voltage. The regulator contacts vibrate this way at the rate of about 100 times a second and this holds the voltage at a point determined by the strength of the regulator spring or its tension.

The cut-out is electromagnetic with two windings and is carried in the same case with the regulator, this case being on top of the dynamo. All connections between dynamo, regulator and cut-out are made between the regulator housing and dynamo case and are not exposed. Two wires only come from the dynamo, one positive and one negative.

The dynamo wires end in a brass plug on one end of the regulator case. This plug may be rotated in its socket so that it makes part of a turn one way or the other. Turning this plug as far toward the engine as it will go makes one wire positive and the other negative, and turning it as far from the engine as it will go reverses this polarity. This reversal should be made every 500 miles, being sure that the plug is turned as far as it will go so that it locks in place. This action reverses the polarity of the dynamo and prevents pitting of the contacts.

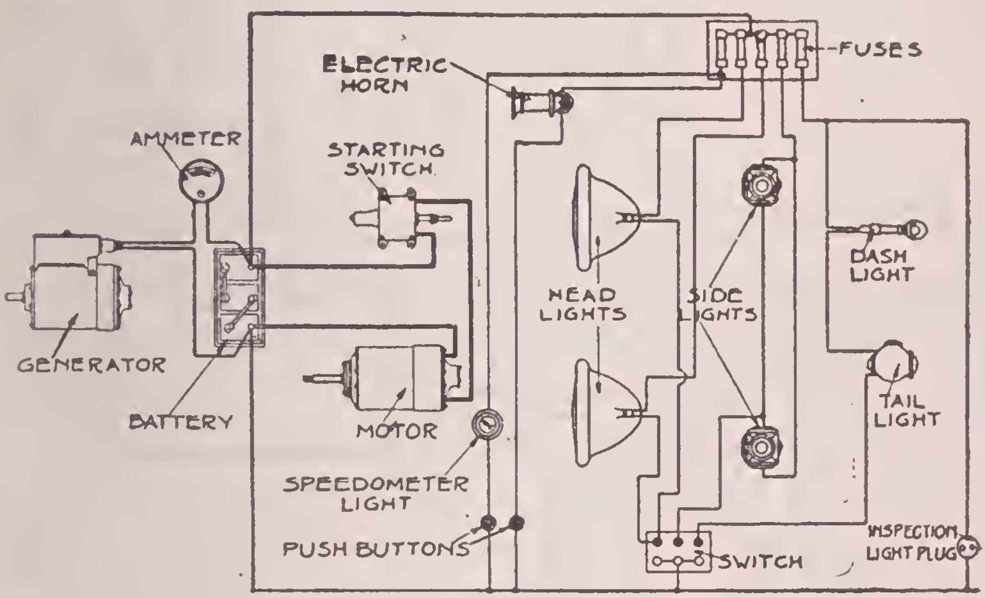


Fig. 270

Bijur Wiring Diagram for Voltage Control System

After adjustments are made the regulator box is sealed at the factory and the maker's instructions say not to open it. The entire box may be removed from the dynamo by unscrewing the small milled nut on top, the connections between the cases being made with split pins. Lights and starter will run from the battery while the regulator is returned to the makers for repairs. A complete wiring diagram for this form of Bijur apparatus is shown in Fig. 270.

In Fig. 271 is shown the application of another form of six-volt separate unit system.

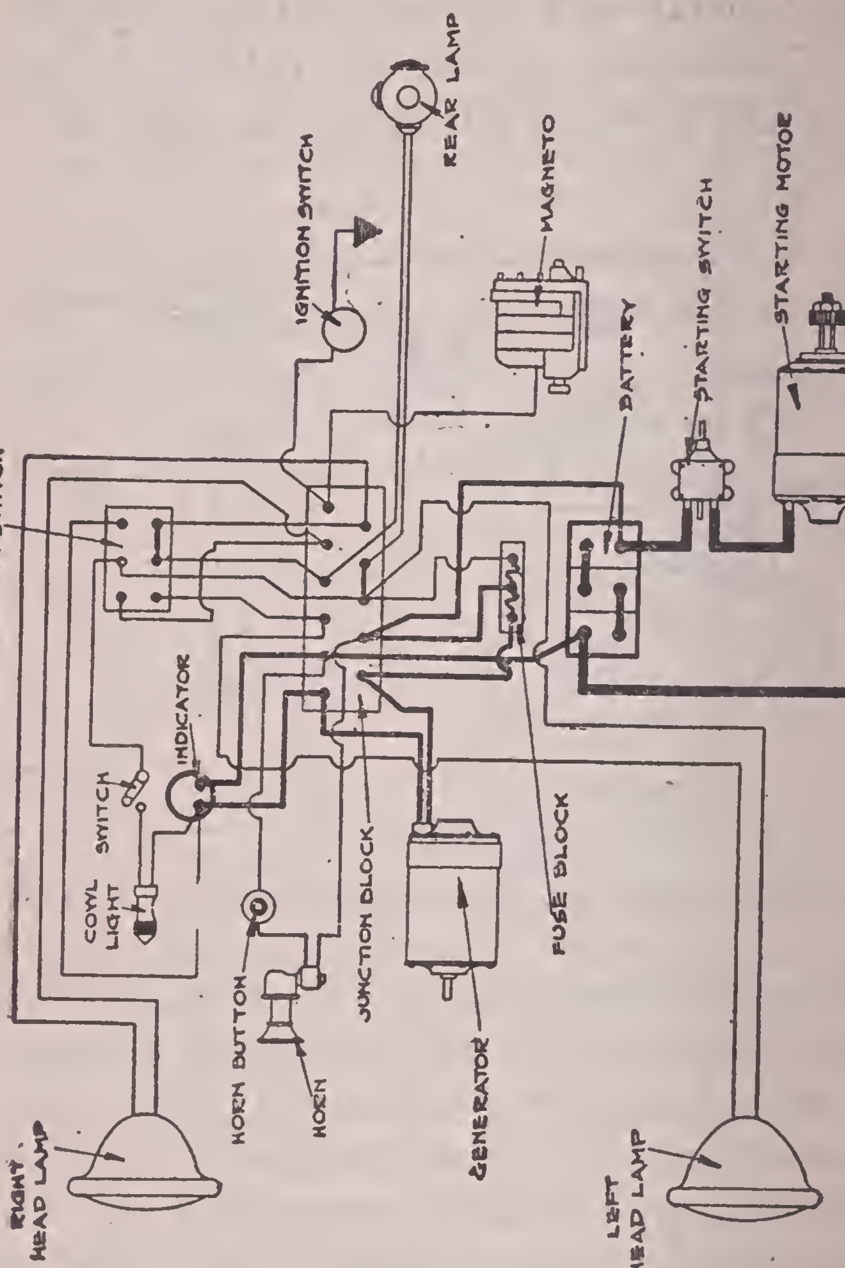


Fig. 271
Bijur Wiring Diagram for Third Brush Dynamo

This dynamo has no controller box as has the one just described, but the shunt field winding is connected to an additional brush bearing on the dynamo commutator. This brush is for the purpose of limiting the dynamo amperage and is so placed in relation to the main brushes that the current passing into it, and thereby into the shunt field, diminishes with increase of speed. The normal tendency of the output to increase with the speed of rotation is therefore counteracted and a safe maximum is maintained. This is the form of regulation known as "third brush."

The electromagnetic cut-out for this system is mounted inside of the brush and commutator end of the dynamo case. This end of the machine is closed by a removable brass band, and through the openings left with this band removed the working parts of the machine may be inspected. Mounted on the outside of the dynamo case, and connected in series with the field windings, is a small fuse which will blow out whenever the current passing through the fields becomes excessive. This fuse will protect the dynamo in case of a broken circuit between dynamo and battery or lamp lines.

Separate starting motors of Bijur make may drive to the engine through an overrunning clutch, through direct acting spur gears or by means of a Bendix screw. With the Bendix screw, a single contact starting switch is used which sends the full battery current to the motor when the switch is closed. With the spur gear drive, the starter switch makes a preliminary contact through a resistance coil and continued movement of the switch pedal and plunger closes the contacts that short circuit the resistance and send the full battery current through the motor. The same operation that meshes the starting gears moves the switch plunger.

Bijur motor-dynamos operate at twelve volts and have their output controlled by the "third brush" system as explained for the type just described. Drive is direct to the engine crankshaft through a silent chain. No cut-out is used, but when the motor-dynamo is connected to the battery by means of the starting switch, the switch is allowed to remain closed and the increasing speed of the unit when driven from the engine causes the voltage as a dynamo to rise to a point that recharges the battery. When the car is operated at a speed below about ten miles an hour, the dynamo voltage falls below that of a battery and the unit again becomes a starting motor. A neutral position is provided on the starting switch for use when the car is being driven at low speeds or when the engine is idling. With the switch in this position the motor-dynamo is disconnected and battery discharge is prevented.

Bosch Equipment. The dynamo is shown in Fig. 272 and is used in connection with a starting motor of the Rushmore type and having the Rushmore form of drive to the flywheel.

The dynamo is a separate unit, shunt wound, delivering 12 volts with a maximum output of

8 to 10 amperes at high car speeds with a partially discharged battery.

A box mounted on the dash carries a volt-ammeter, voltage regulator, cut-out, lighting and ignition switches and fuses. A small lever is moved to cause the meter to show either volts or amperes on the same meter.

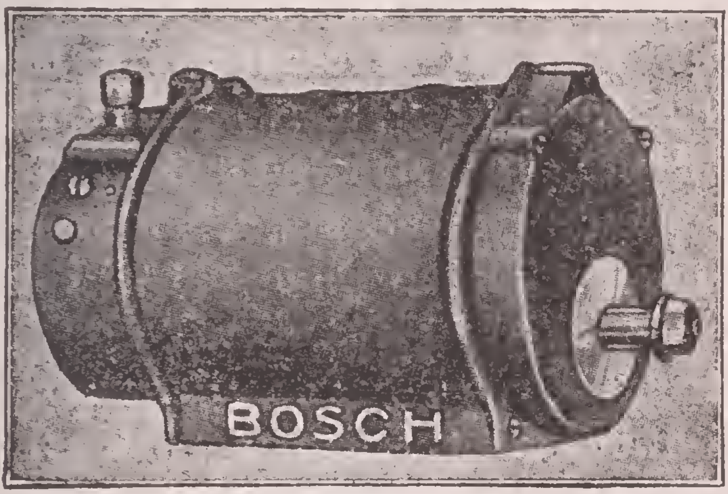


Fig. 272
Bosch Dynamo

Regulation acts to maintain a steady voltage. The regulator consists of a small cylinder of carbon particles with one end of the shunt field winding connected to one end of the carbon pile and the corresponding dynamo brush connected to the other end of the carbon. The shunt field current thus passes through the carbon. The carbon particles are held tightly compressed by a plunger fitting inside the cylinder with a coil spring holding the plunger down. Under this condition the resistance of the carbon is very low and allows practically the whole of the shunt field current to pass without interruption. An electromagnet forms part of the regulator and is connected in shunt across the dynamo brushes so that its strength increases with the rise in voltage. This electromagnet acts to pull up on the plunger against the action of the spring, and as the voltage rises the pressure on the carbon is lessened in this way and the resistance of the carbon pile increases rapidly as the particles are loosened. This resistance in the field lowers the voltage and output.

An electromagnetic cut-out is carried in the dash unit housing with the voltage regulator. These systems make use of the single wire, ground return method of wiring. The starting cable is, however, covered with a copper sheath that assists in carrying the return current to the battery.

Delco Equipment. A majority of Delco applications have been of the motor-dynamo type, this method being departed from for the first time on some of the applications made on 1916 cars. The first Delco system to be used consisted of a motor-dynamo that operated as a starter at 24 volts and charged to six volts for lighting and battery charging. The battery for this system consists of twelve cells divided into four sections of three cells each. By means of a two position multiple contact knife switch carried in the battery box, these sections were placed in series for starting and in parallel for lighting and charging. The complete charging circuit diagram is shown in Fig. 273.

The battery charge is controlled by a form of wattmeter, called an ampere-hour meter. Current flowing into the battery causes this meter to revolve in one direction and current

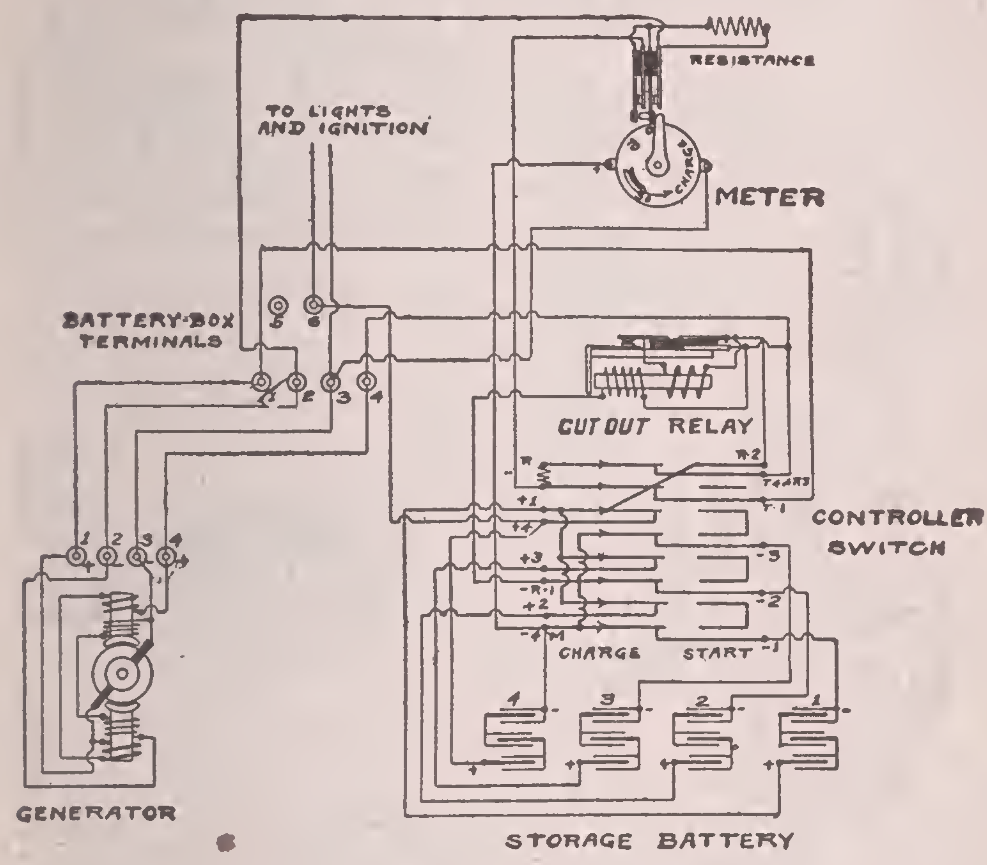


Fig. 273
Charging Circuit of Delco 6-24 Volt System

flowing out of the battery causes it to revolve in the opposite direction. After a certain flow has entered the battery, the meter has moved to such a position that a resistance is inserted in the shunt field winding of the dynamo and the rate of charge is thereby reduced. Further

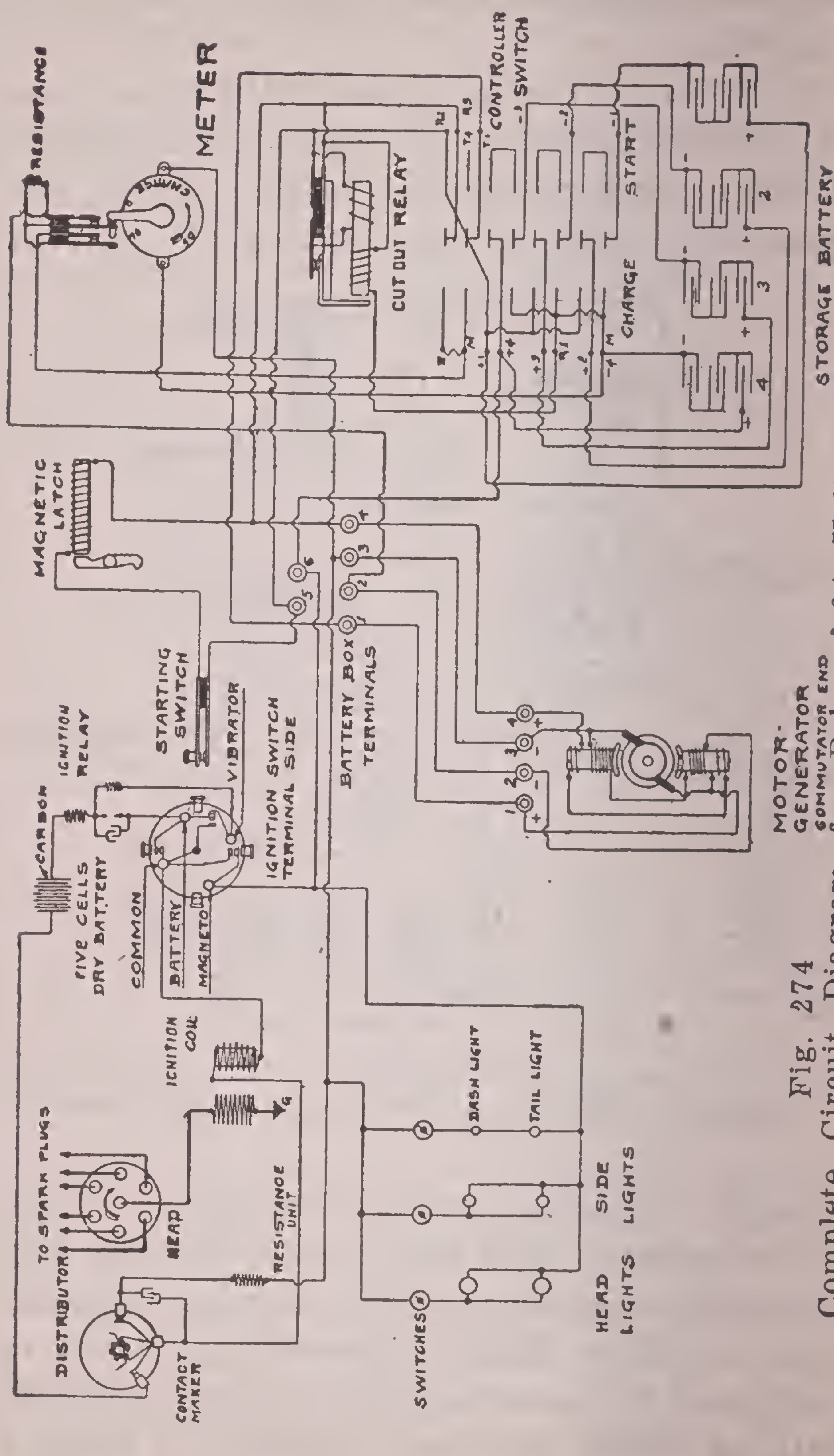


Fig. 274
Complete Circuit Diagram for Delco 6-24 Volt System

movement of the meter in the same direction opens the shunt field current and further battery charge is prevented. Withdrawal of current causes the meter to reverse this movement and the field circuit is first closed through the resistance and the resistance is then cut out entirely, allowing a resumption of full battery charge.

Fig. 274 shows the complete circuit diagram for this system. The magnetic latch is for the purpose of allowing the driver to close the starting switch and mesh the motor gears with the flywheel when the clutch pedal is depressed. By means of a small push button, usually on the heel board, the latch magnet is energized and the latch itself connects the starting gearing with the clutch pedal. Depression of the pedal then causes starting action as described. The application of this system on a car, with external wiring shown, is seen in Fig. 275.

A form of Delco motor-dynamo having two separate commutators and two sets of brushes is shown in Fig. 276. One of these commutators is for the dynamo generating action, while the other is for starting.

When the unit is generating current for charging the battery, for lights and ignition, it is a simple shunt wound generator. It is driven from the engine by an extension of the pump shaft. The generator is driven at one and one-half crankshaft speed, and in order to compensate for the higher ratio when the

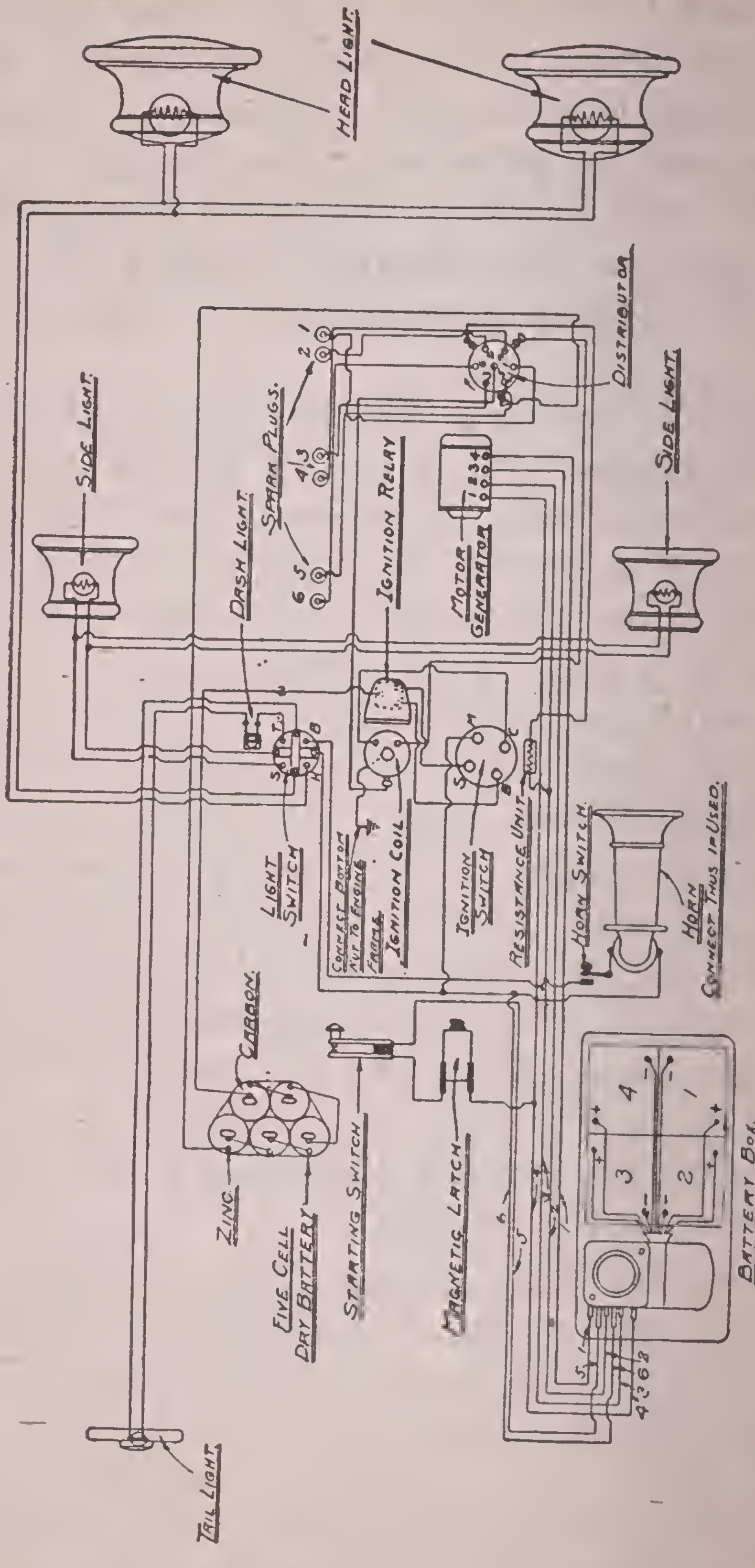


Fig. 275 Complete Car Wiring for Delco 6-24 Volt System

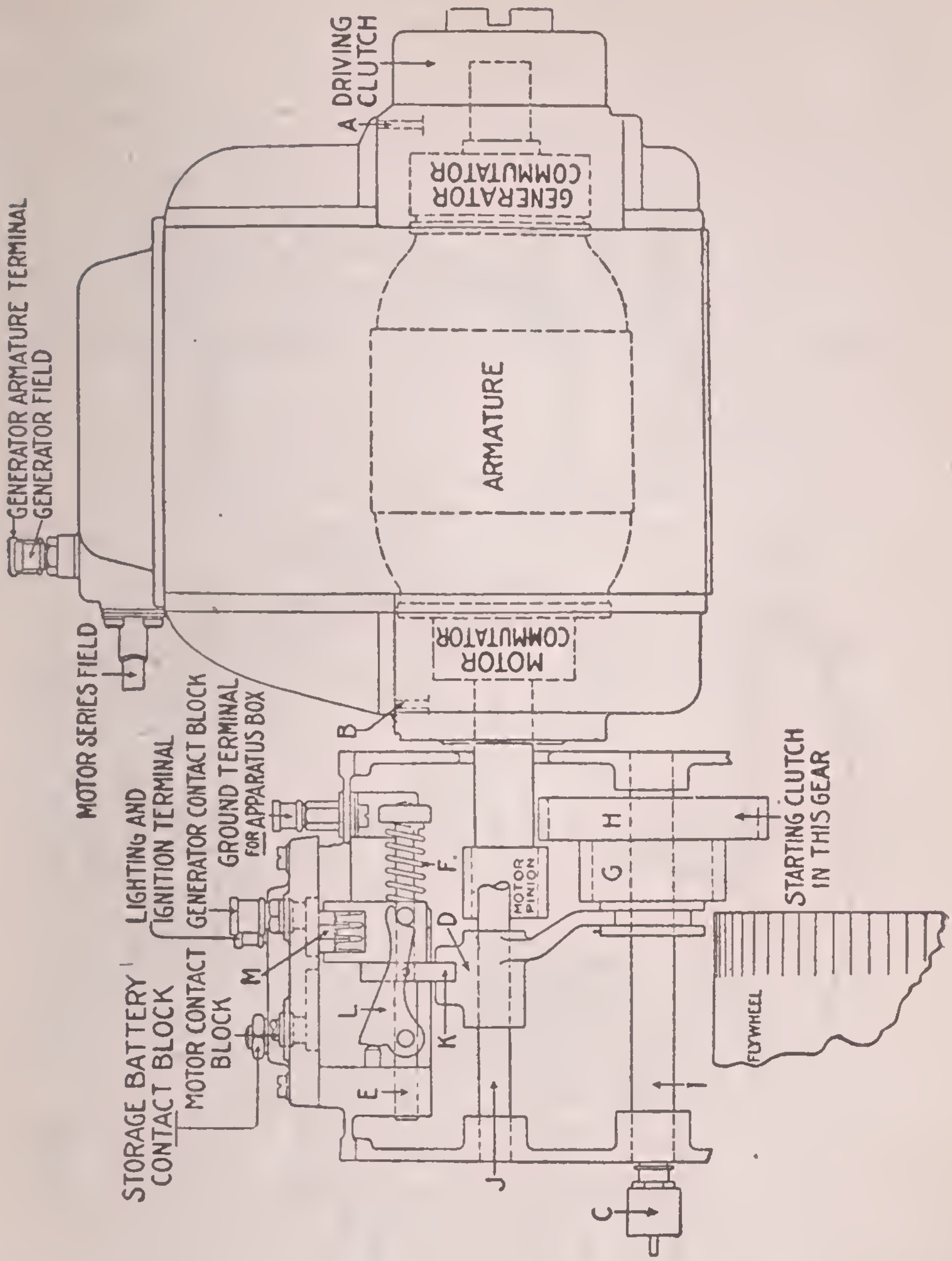


Fig. 276

Delco Motor-Dynamo With Starter Switch Mounted Above Flywheel Drive Gearing. A, Oil Hole. B, Oil Hole. C, Grease Cup. D, Gear Shift Yoke. E, Switch Operating Rod. F, Switch Spring. G, Flywheel Gear. H, Motor Pinion Gear. I, Clutch Shaft. J, Shift Yoke Rod. K, Tripping Collar. L, Contact Block Latch. M, Contact Block.

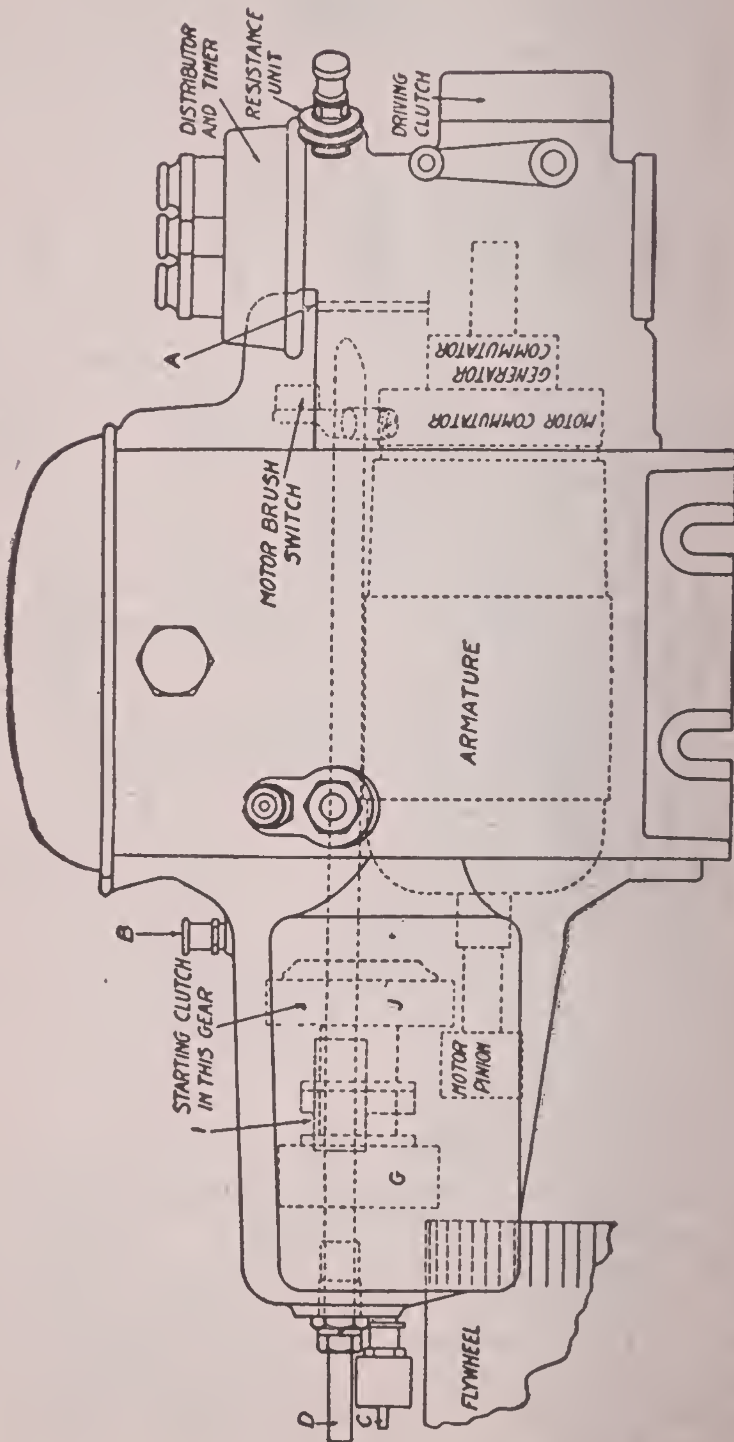


Fig. 277
Delco "Junior" Motor-Dynamo

unit is in starting relation to the engine, a second one-way clutch is provided adjacent to the forward housing. This clutch permits the armature to run ahead of the driving shaft during the cranking operation.

Fig. 277 illustrates the Delco "Junior" motor-dynamo and the starting switch is shown

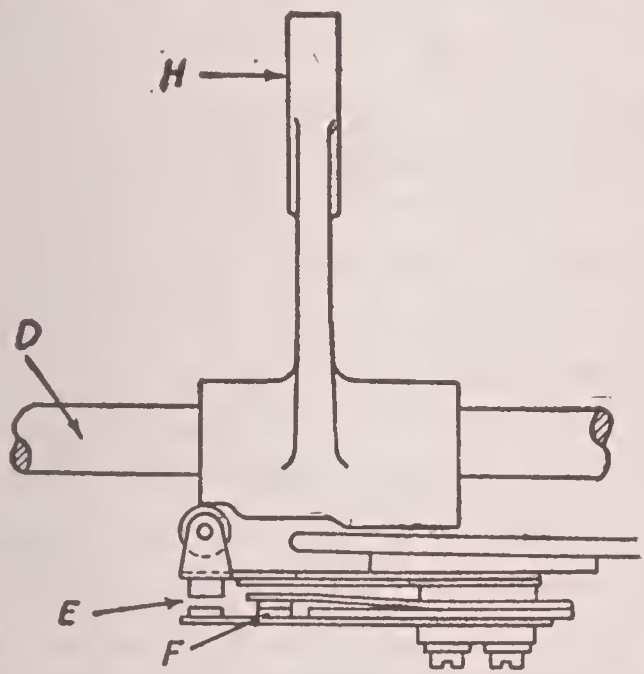


Fig. 278
Delco Starting Switch

in Fig. 278. These units cannot well be shown in their actual locations and are therefore shown separate. Referring to Figs. 277 and 278, the yoke H fits into the collar I which is pinned to the rod D. The movement of the rod from the starter pedal operates the gearing and the starting switch.

When the starting pedal is pushed down it pulls back the rod D and closes the contact E, which completes the circuit between the battery and dynamo armature. The closing of the circuit causes the armature to revolve slowly so that the gear J will mesh with the motor pinion as it slides along on its shaft. As the starting pedal is pushed further down it continues to pull the rod D, which opens the contact F, breaking the circuit between the battery and dynamo armature. This action of the rod at the same time causes the motor brush switch to drop onto the motor commutator, and the train of gears to slide on its shaft until in mesh with the motor pinion and the teeth on the flywheel.

The motor brush dropping on the commutator causes the circuit to be closed between the storage battery and the motor armature, which causes the motor to crank over the engine.

When the starting lever is released the motor switch brush is raised from the motor commutator and the train of gears is thrown out of mesh, when the contacts F will automatically close.

If the speed of the motor generator is above 350 revolutions per minute, the cut-out relay, Fig. 279, will close the circuit between the storage battery and motor generator, thus permitting the generator to charge the storage battery. If the speed of the motor generator is less than 350 revolutions per minute, the cut-out relay will remain open and all current for ignition and lights, if they are in use, will come from the storage battery.

Oil is conveyed to the ball bearings through oil cup B and the small hole A in the front end cover. This hole is made accessible by removing the upper front end cover. At the time 4 or 5 drops of light oil are put in the oil cup B and the hole A, the grease cup C should be

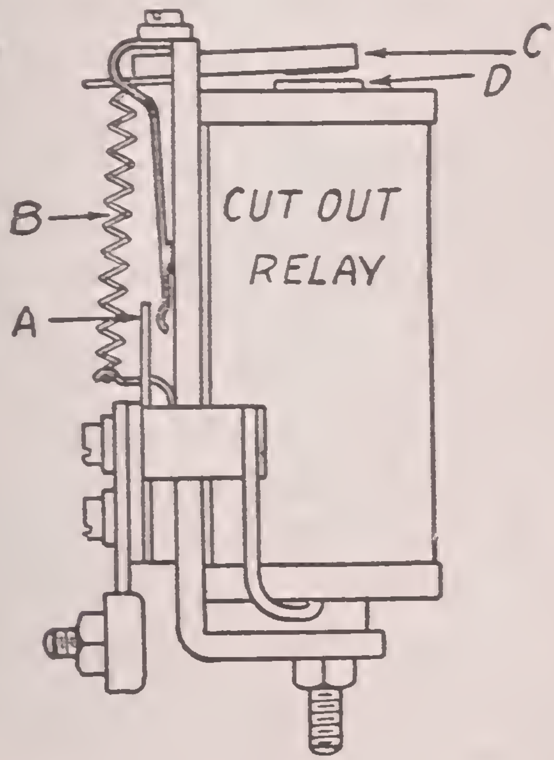


Fig. 279
Delco Reverse Current Cut-out

given 1 or 2 turns or replenished if empty.

The cut-out relay, Fig. 279, is located in the rear end housing of the generator. This instrument closes the circuit between the generator and the storage battery when the generator voltage is high enough to charge the storage battery. It also opens the circuit as the generator slows down and its voltage becomes less than that of the storage battery, thus preventing the battery from discharging back through the generator. The cut-out relay is an electromagnet with a compound winding. The voltage coil or fine wire winding is connected directly across the terminals of the generator. The current coil, or coarse wire winding, is in series with the circuit between the generator and the storage battery, and the circuit is opened and closed at the contacts A. When the engine is started, the generator voltage builds up and when it reaches about six volts a current passing through the voltage winding produces enough magnetism to overcome the tension of the spring B, attracting the magnet armature C to core D, which closes the contacts A. These contacts close the circuit between the generator and storage battery. The current flowing through the coarse wire winding increases the pull on the armature and gives a good contact of low resistance at the contact points.

Delco systems used during 1915 consist of single armature motor-dynamos, one application of which is shown in Fig. 280. The armature carries two commutators, one on each end or both on the front end, the rear end commutator being for the starting motor action.

Two separate field coils are used; a shunt for

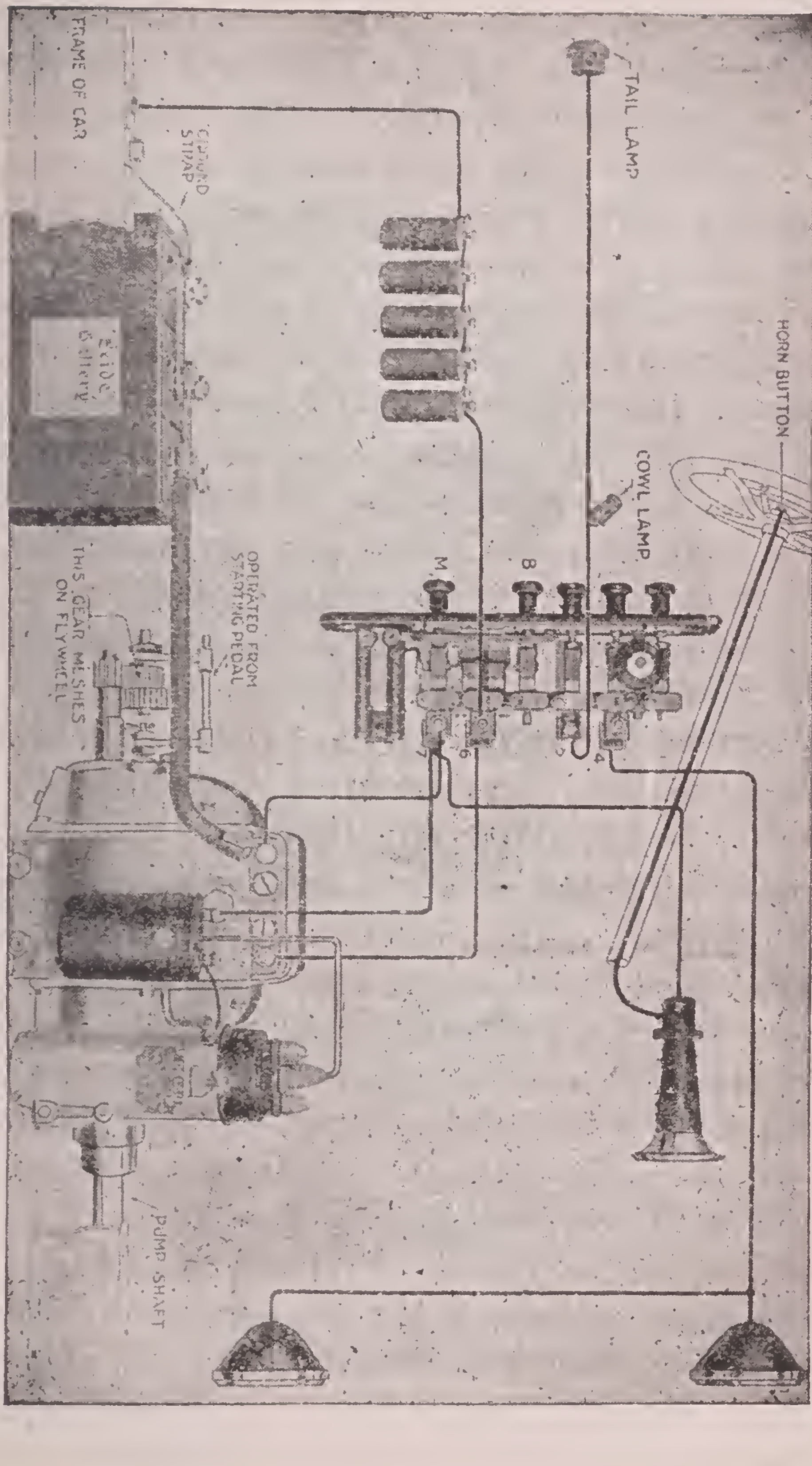


Fig. 280 Delco Starting and Lighting System, 1915 Type With Governor Control for Amperage

the dynamo action and a series for the starting motor action. These coils are both on the same field magnet core and have separate terminals. The drive as a dynamo is from the rear extension of the pump shaft through a roller overrunning clutch which releases when the armature turns at high speed as a starting motor.

The starting motor drive is through a pinion on the rear end of the armature shaft to a ring gear on the flywheel. Two gears, fastened together, are free to rotate as a pair on an auxiliary shaft, the gears being slid along this shaft by a yoke connected to the starting pedal until one is in mesh with the armature shaft pinion and the other with the flywheel gear, completing the drive connection. A roller clutch is incorporated in the front one of the pair of sliding gears, this clutch releasing while the armature is being driven as a dynamo.

Starting switch action is secured by normally holding one of the motor commutator brushes away from the commutator by means of a rod connected to the starting lever or pedal. When the lever or pedal is moved this rod is drawn back so that the brush drops onto the commutator under the action of its spring, completing the circuit from the battery through the series winding and armature. This rod is fastened to the sliding gears so that they must be in mesh before the brush can drop.

The dynamo brush that is grounded completes its connection to ground through a pair of contacts, one stationary and one movable, Fig. 281. The movable contact is attached to an arm on the movable starter brush in such a

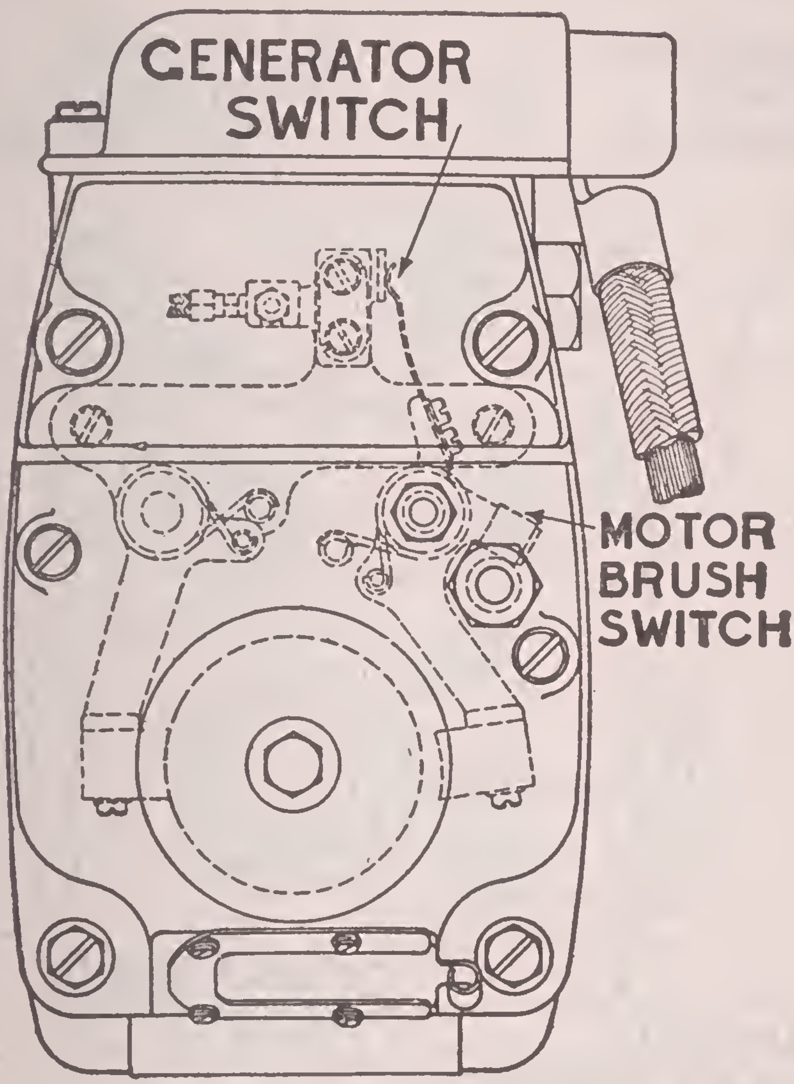


Fig. 281
Commutator End of Delco Governor Controlled Motor-Dynamo

way that the contacts open as the starter brush drops onto the commutator. This prevents dynamo action while the armature is acting to start the engine.

No fuses are used, but there is a magnetic circuit breaker, the electromagnet of which acts to open the contacts from the battery and dy-

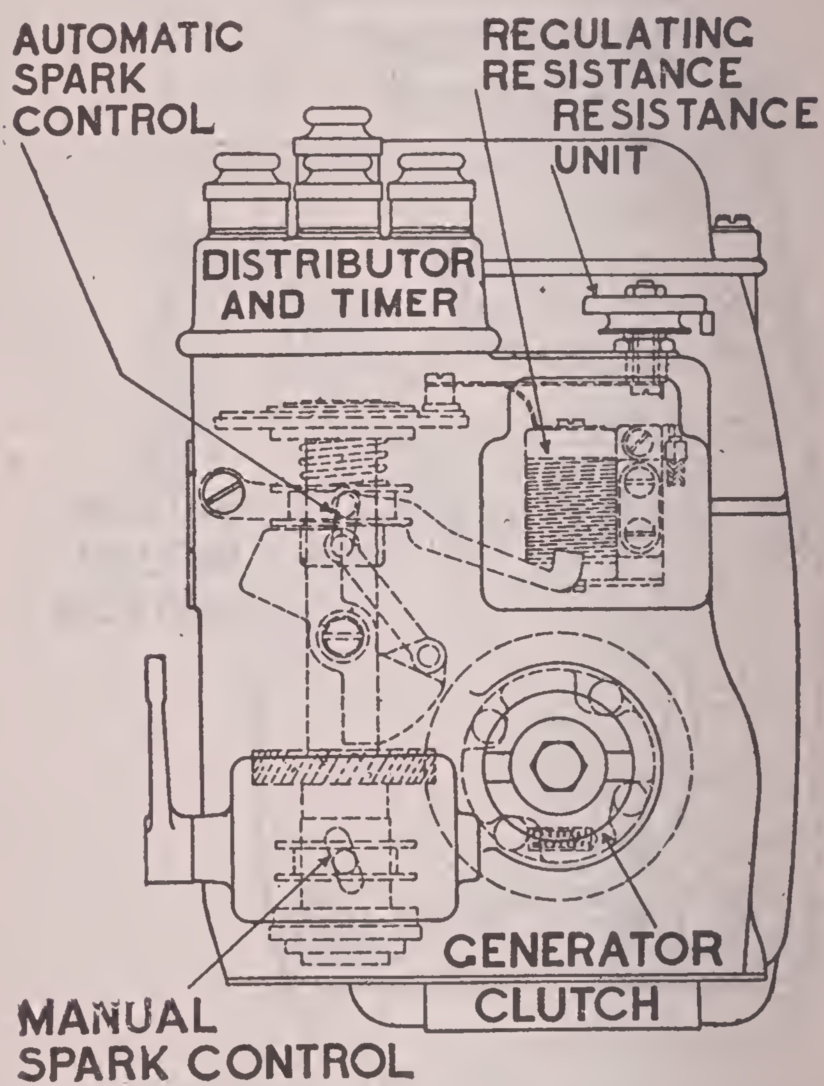


Fig. 282

Governor and Overrunning Clutch Mechanism of Delco Motor-Dynamo

namo to the lamp and car wiring when 25 amperes flow. After the circuit breaker opens the contacts continue to vibrate open and closed if there is a flow amounting to five amperes. The circuit breaker will not stay closed until the ground or short circuit that is causing the leak of current has been removed. The spring of this current breaker should not be adjusted in any way as it is a safety device.

Delco systems may have any one of three different systems for regulating the dynamo output. One type consists of a differential or bucking coil carried on the field magnets and connected in series with the main line from the dynamo brush to the dash switch unit.

Another method makes use of a coil of resistance wire carried on a spool in the front end of the dynamo case on the right hand side, Fig. 282. One end of the shunt field winding is grounded through this resistance coil so that the field current would have to pass through the coil. This high resistance would allow but little flow and would weaken the field to such a point that the output would be very low. When the dynamo is running at low speeds the field current, after passing to the lower end of the resistance coil, goes to the ground through an arm making contact with the coil. This arm carries a contact which slides up and down on the resistance coil, the arm being moved by a centrifugal governor attached to the ignition distributer shaft. As the dynamo speed increases, the governor weights cause the movable arm to raise so that its contact is farther from the bottom of the resistance coil, and the field current must consequently flow through a greater length of resistance wire before reaching the contact on the arm and passing to the ground. This greater resistance in the shunt field circuit allows less current to flow and by thus weakening the field cuts down the dynamo output at high speeds.

The third system of regulation also causes the shunt field current to pass to the ground through a coil of resistance wire. This resistance coil is wound on a spool and the spool is carried at one end of a rod, the other end of the rod forming the plunger of a solenoid coil. The strength of this solenoid increases with the voltage, being connected in shunt with the brushes. Increased strength of the solenoid pulls the plunger farther into the coil. This solenoid coil is in the upper end of a cylindrical housing, and the resistance coil is carried below the solenoid. The plunger and resistance are normally in a low position but are raised by the solenoid action. In the low position the resistance coil dips into a well partly full of mercury so that the shunt field current does not have to pass through all the resistance wire but passes into the mercury and to the ground from a contact fastened to the mercury well. As the voltage rises the solenoid becomes stronger, lifting the plunger and pulling the resistance coil up out of the mercury well so that the shunt field current must flow through a greater length of resistance wire before reaching the ground. This added resistance allows less current to flow through the shunt field and consequently lowers the field strength and the output of the dynamo.

Delco systems use either of two methods of reverse current cut-out. One type comprises a dash switch with five buttons. The three left-hand buttons are for the lights, the two right-hand being for the ignition. The button on the extreme right is for the storage battery ignition, the one next to it being for the dry cells. Each of these buttons carries two contacts inside the switch, one completing the ignition circuit and the other completing the charging circuit. When the engine is to be started either of the ignition switches is pulled out. The current then passes from the battery to contact (1) on the switch, through the inner connection of either dry cell (Bat.) or storage battery (Mag.) switch and out of terminal (6) to the shunt dynamo winding and armature brushes. This causes the dynamo parts to act as a motor of very low power and the armature revolves slowly so that the starting gears can be meshed. As soon as the gears are meshed the motor brush drops onto its commutator and completes the starting circuit while breaking the dynamo circuit as described before. The battery current will then cease to flow through terminal (6) but will flow through the circuit breaker, whose points are held closed by a spring, and through the other connection on the switch button plunger, out through terminal (7) and to

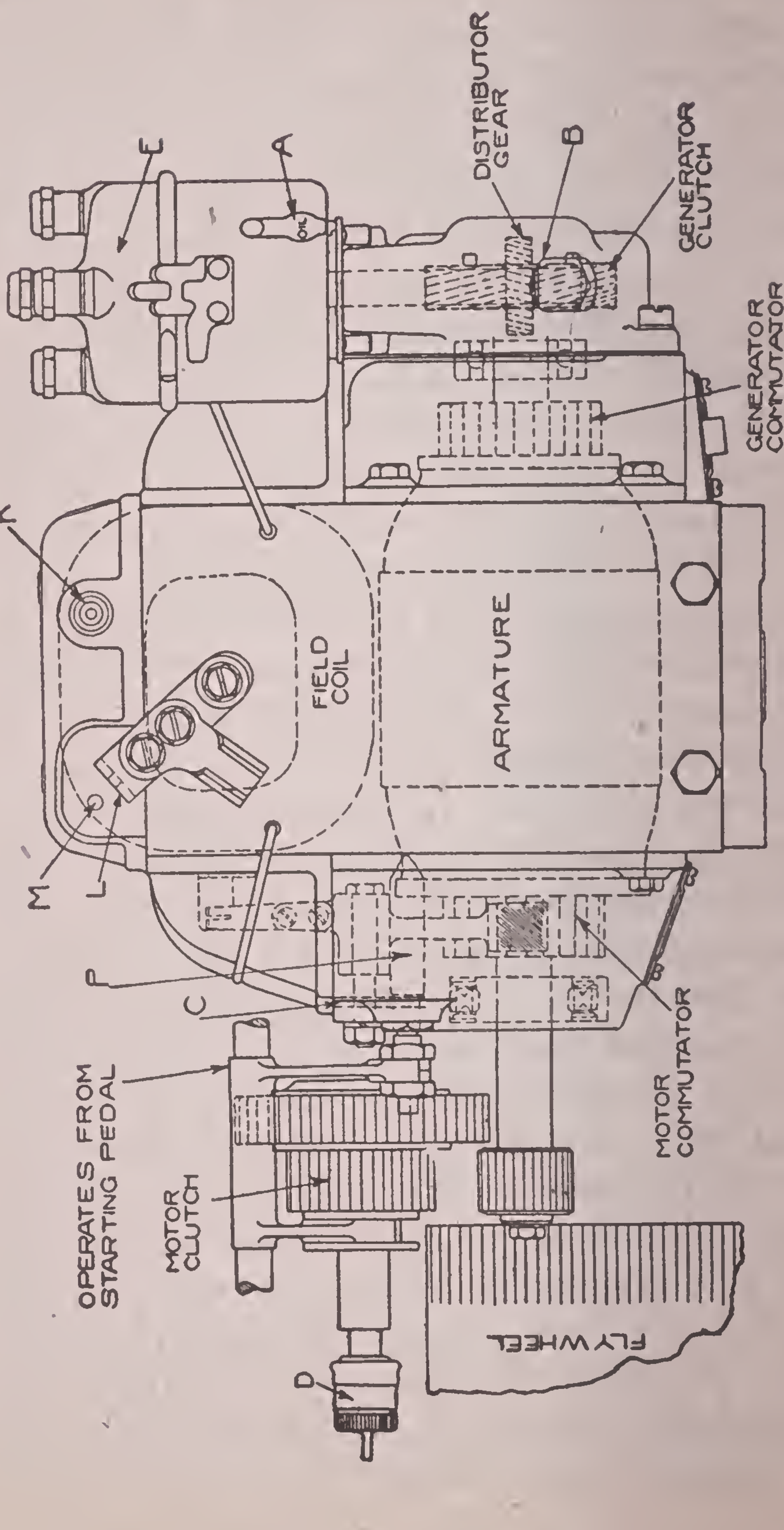


Fig. 283
Delco 1916 Motor-Dynamo With Third Brush Control

the ignition coil. If the "Bat" button is pulled out the dry cell current comes into terminal (2) and out through (7) to the ignition coil. When the engine has been started and the dynamo generates a voltage greater than the battery, current will flow from the dynamo through the differential winding (if one is used) into terminal (6), through the inner contacts of the switch and out through (1) to the battery. If the ignition switches are left closed with the engine idle the battery will discharge through the switch contacts and dynamo parts, these switches acting as the cut-out with the dynamo and engine idle.

The construction of Delco apparatus used during 1916 differs from that already described in one important particular. The output of the dynamo when charging the battery is controlled by the "third brush" principle.

One of the applications is shown in Fig. 283 and it will be noted that the armature and field location, starting drive and ignition mechanism is similar to the forms previously used. The brush position is shown in Fig. 284. The action is explained as follows: The full voltage is obtained between the large brushes and the voltage between the left hand large brush and the small regulating brush is less than the full pressure. This reduced voltage is applied to the field coils. With the armature rotating, the magnetic field is twisted out of its normal path between the pole pieces, the degree of deflection being in direct ratio to the increase of speed. This deflection causes the magnetic flow to be-

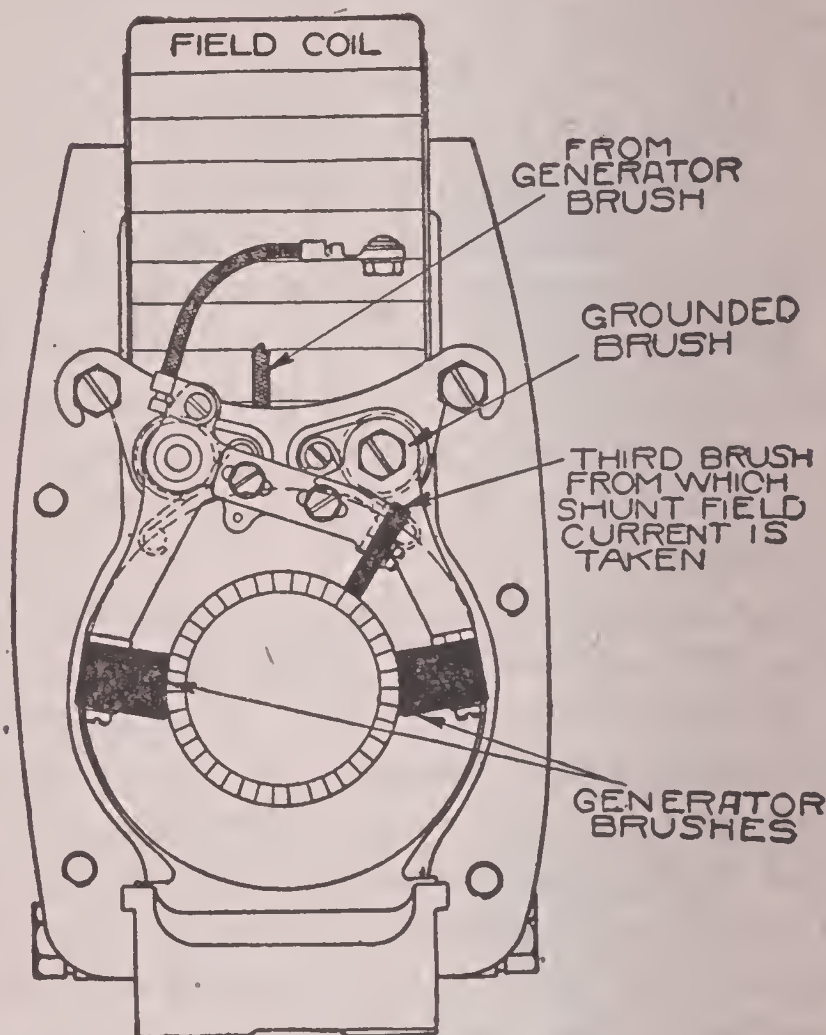


Fig. 284
Brush Mechanism of Delco Motor-Dynamo

come weaker at the points on the pole pieces that affect the flow into the "third brush" and this weakened field current compensates for the higher output that would otherwise be caused by increase of speed. Fig. 285 shows the starting motor end of this same machine.

Another application of the third brush dynamo does not make use of the motor-dynamo

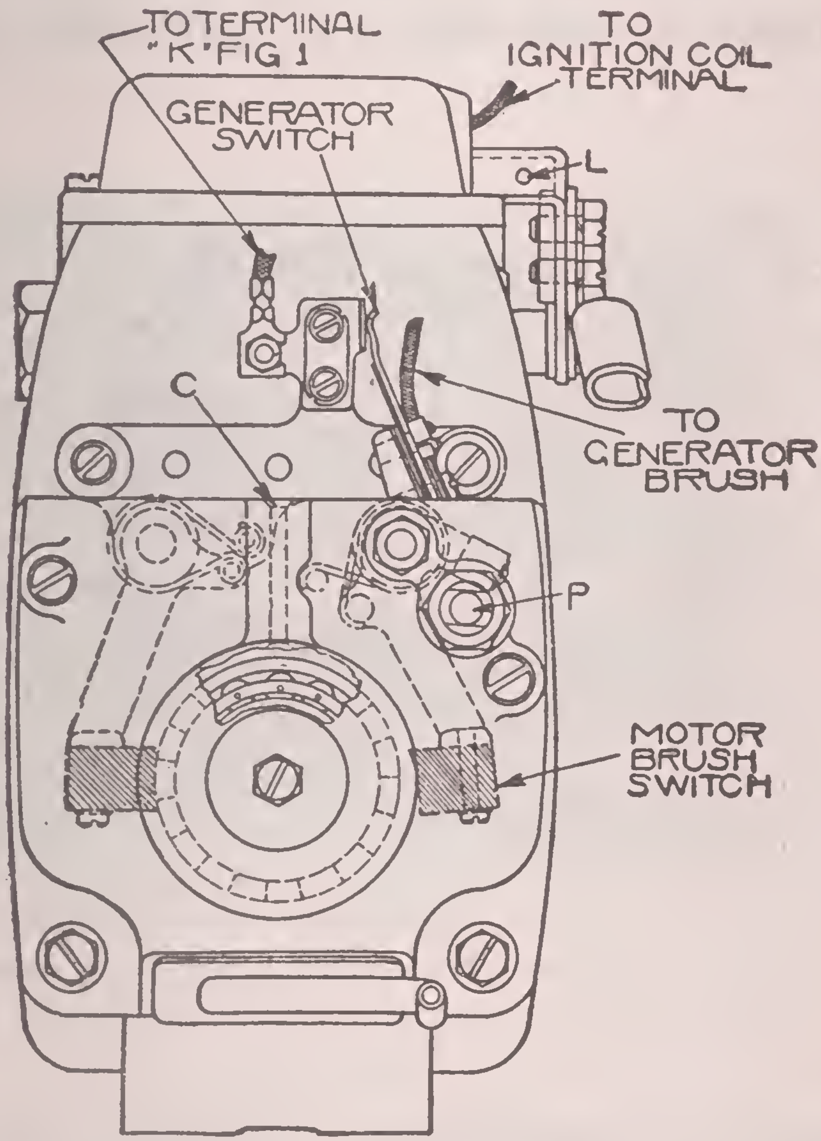


Fig. 285

Motor Brush Switch Connections of Delco Motor-Dynamo

combination, but uses a separate series wound motor driving to the flywheel through a Bendix screw.

Dyneto and Entz Equipment. These installations make use of a combined motor-dynamo operating with twelve volts in some cases and with eighteen in others. A compound field winding is used, series and shunt coils acting

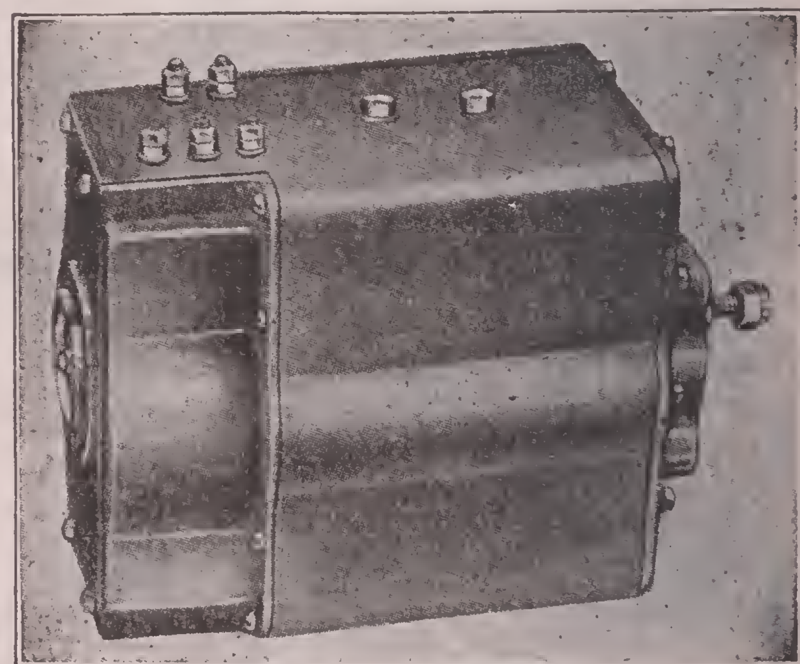


Fig. 286
Five Terminal Dyneto-Entz Motor-Dynamo

together in starting and forming a reversed series controlled machine in generating. The reversal of the direction of flow through the series field while generating causes this winding to oppose the shunt winding at high armature speeds and the dynamo output is thereby limited to a safe maximum.

Dyneto and Entz outfits do not make use of a cut-out of the usual form. The motor-dynamo is placed in circuit with the battery when the starting switch is closed and this switch is left closed as long as the machine operates. As soon as the unit has started the engine, the

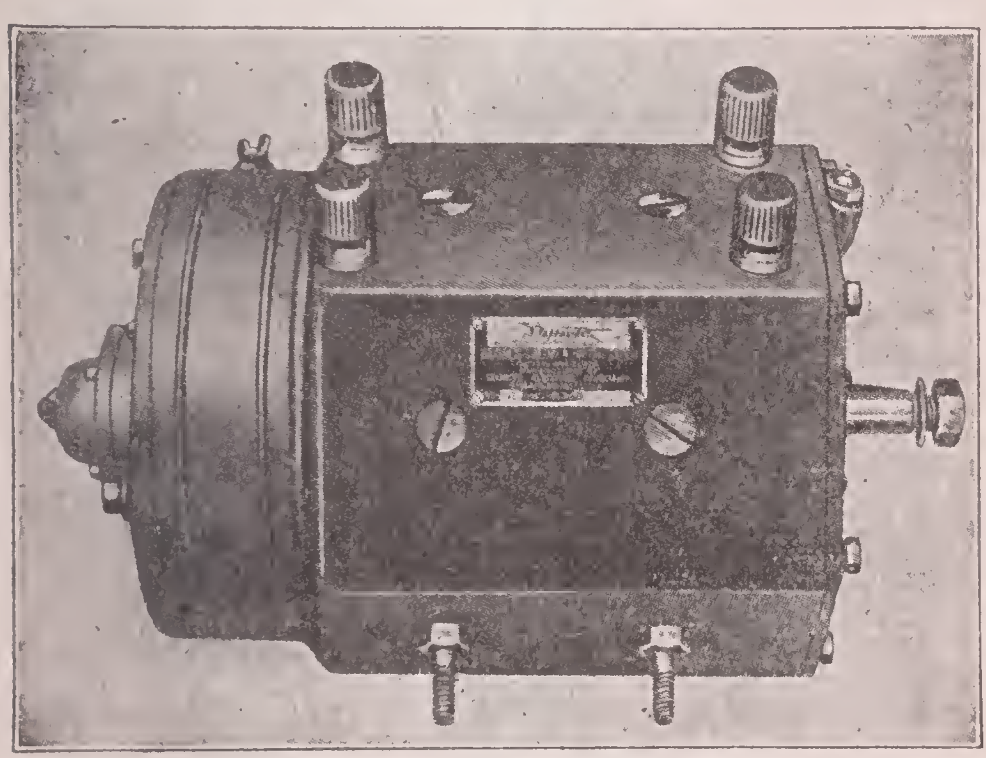


Fig. 287
Four Terminal Dyneto Motor-Dynamo

engine causes the armature speed to increase to a point at which the voltage is greater than the battery and charging then commences. If, at any time, the armature speed falls below a certain point the machine again resumes its action as a starting motor.

The ignition is controlled by the same switch that makes the battery and motor-dynamo circuit. With this switch in the "Off" position, the ignition is inoperative and the battery is disconnected from the motor-dynamo. With the switch in the "On" or "Running" position, the ignition is on and the battery is connected to the electric machine. A switch position midway between the two mentioned is provided, this position being called "Neutral." With the switch at "Neutral," the ignition is operative but the motor-dynamo circuit is open so that the battery will not discharge, and the machine will not act as a starting motor at low engine speeds.

The number of terminals differs on various types; one with five connections being shown in Fig. 286 and another unit with four terminals being illustrated in Fig. 287.

Gray & Davis Equipment. The type of equipment used from 1912 to 1914 is described below.

This system comprises two units: 1, the starting motor; 2, the dynamo for charging

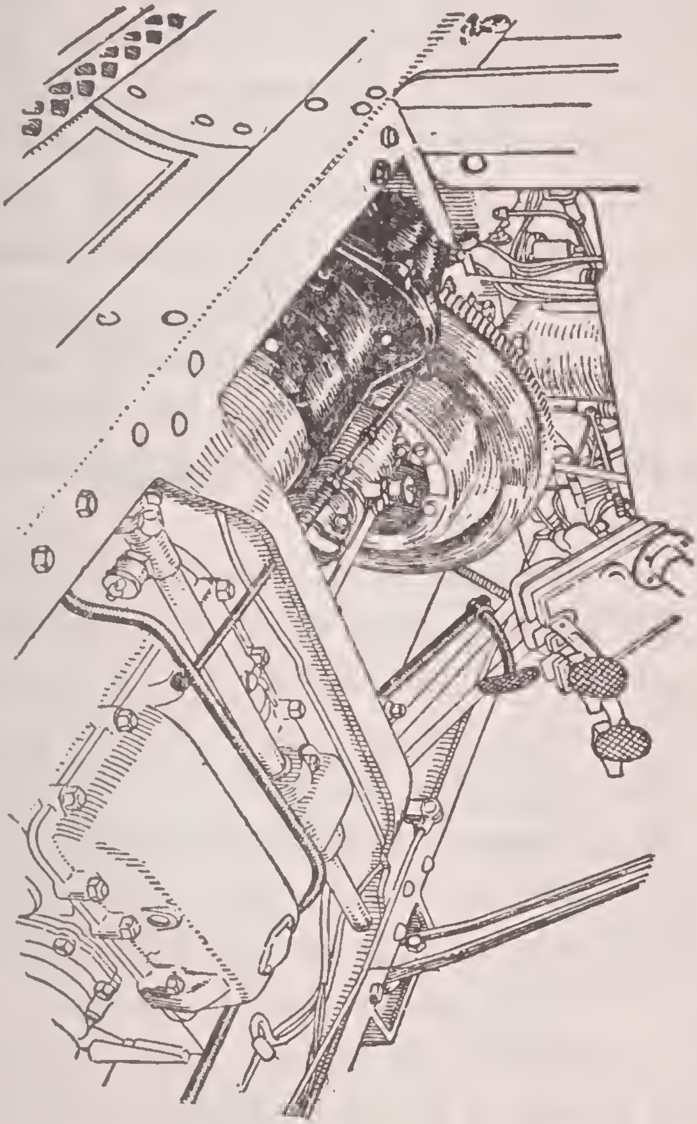


Fig. 288—Gray & Davis Electric Starter on Car.

battery and lighting. The function of the dynamo is to furnish current for lamps and current for the battery. The starting motor starts the engine. This motor is connected with the flywheel by gears, and when a starting pedal is pressed the motor turns the flywheel and crankshaft and keeps turning until the engine "picks up." The starting motor then automatically ceases to operate.

The dynamo system includes the following: 1, a constant-speed dynamo, driven from the engine or jackshaft by gear or a silent chain; 2, a governor, to take care of the varying speed of the engine; 3, an electric cut-out, to disconnect the dynamo from the battery when running below the charging speed; 4, a battery to operate the lights when the dynamo is not running at the necessary speed or when the engine is stopped. This battery may also be used for firing the engine.

1. The dynamo is of the compound-wound type, designed to run at a constant speed of 1000 revolutions per minute. The system is so wired that the series field is carrying current only when the lights are burning. See Fig. 289.

2. The governor is of the simple, centrifugal type, but operates a friction clutch of new design. In operation the clutch slips just enough to hold the dynamo speed always at 1000 r. p. m., whether the engine speed corresponds to a car speed of 13 or of 60 miles an hour.

3. The electric cut-out consists of an electro-magnet with a compound winding, the fine wire part of which is connected across the dynamo terminals. Its function is, as stated, to disconnect the dynamo from the battery when the engine is running very slowly or is at rest.

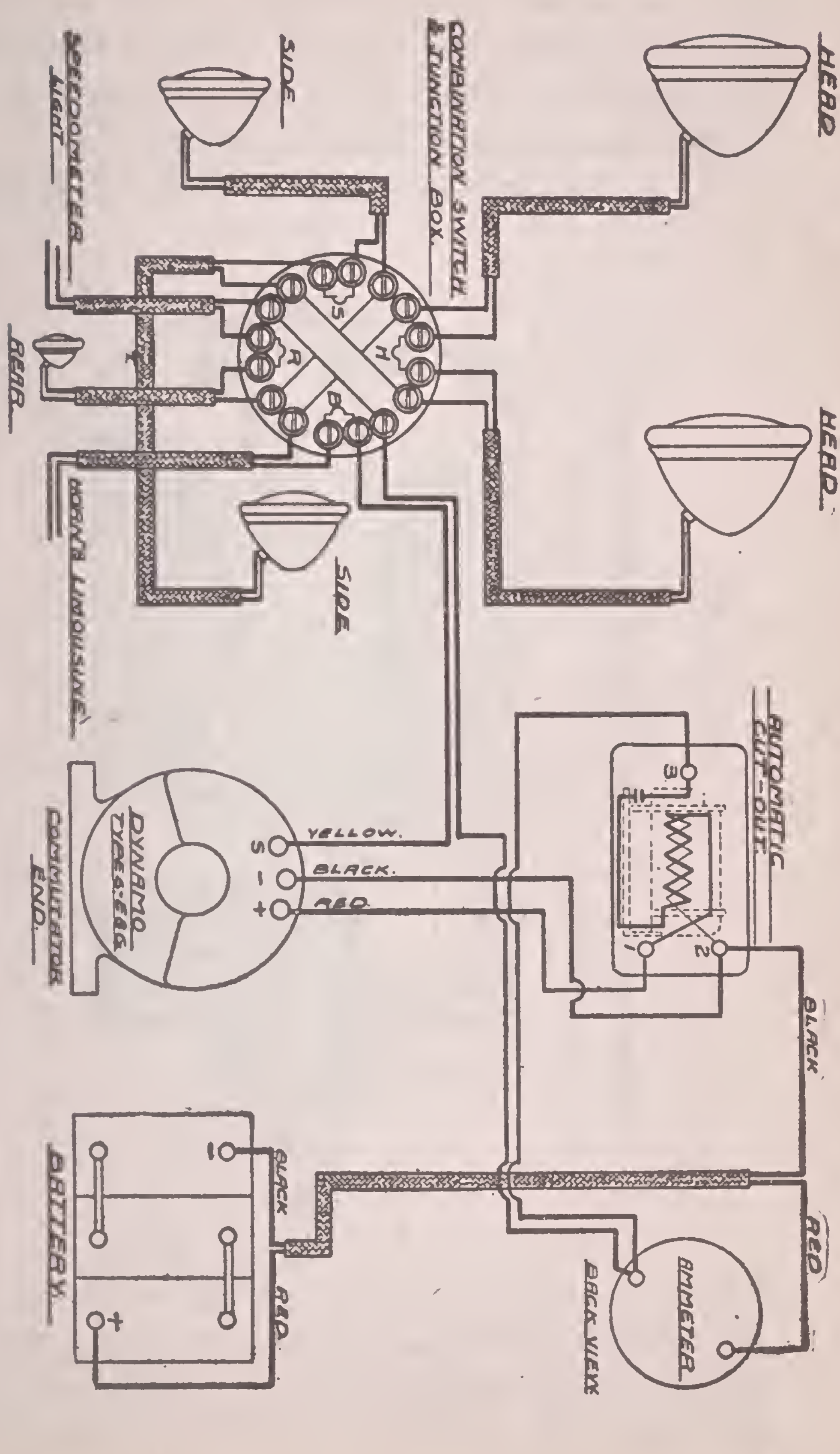


Fig. 289—Wiring Diagram G. & D. Dynamo System.

If an automatic switch of this nature were not in the circuit the battery would discharge through the dynamo when the dynamo was no longer maintaining charging voltage.

4. A battery rated at 6 volts, 80-ampere

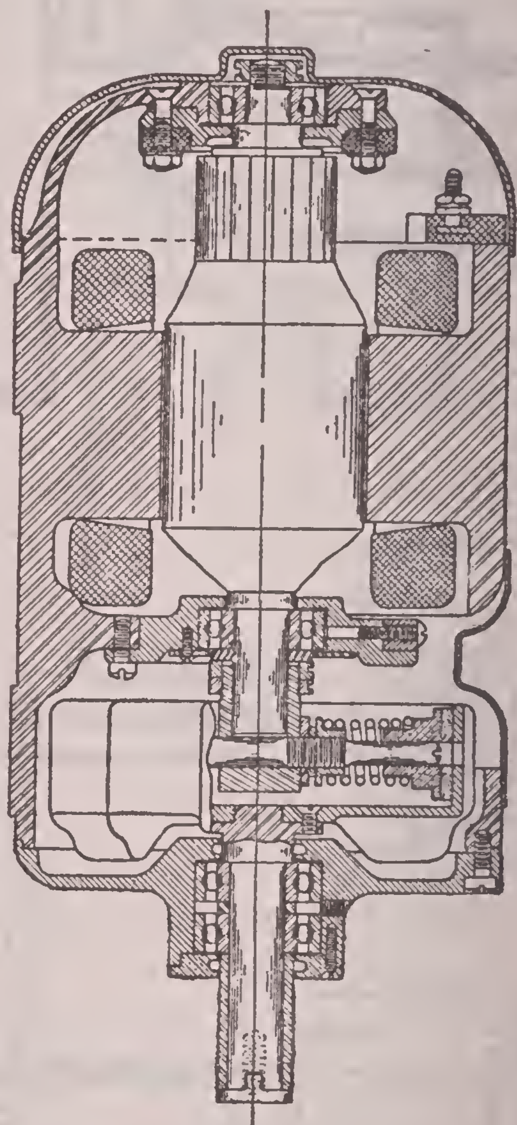


Fig. 290—G. & D. Type "G" Dynamo. Outline Showing Dynamo and Governor Mechanism.

hour capacity at a discharge rate of 8 amperes is furnished with this system sufficient to carry the full lamp load for ten hours or the side and tail lamps for thirty hours. The arrangement of the switch connections is such that the dynamo operates as a shunt-wound machine while charging the battery and as compound-wound when supplying the lamps directly. This gives the battery a tapering charge.

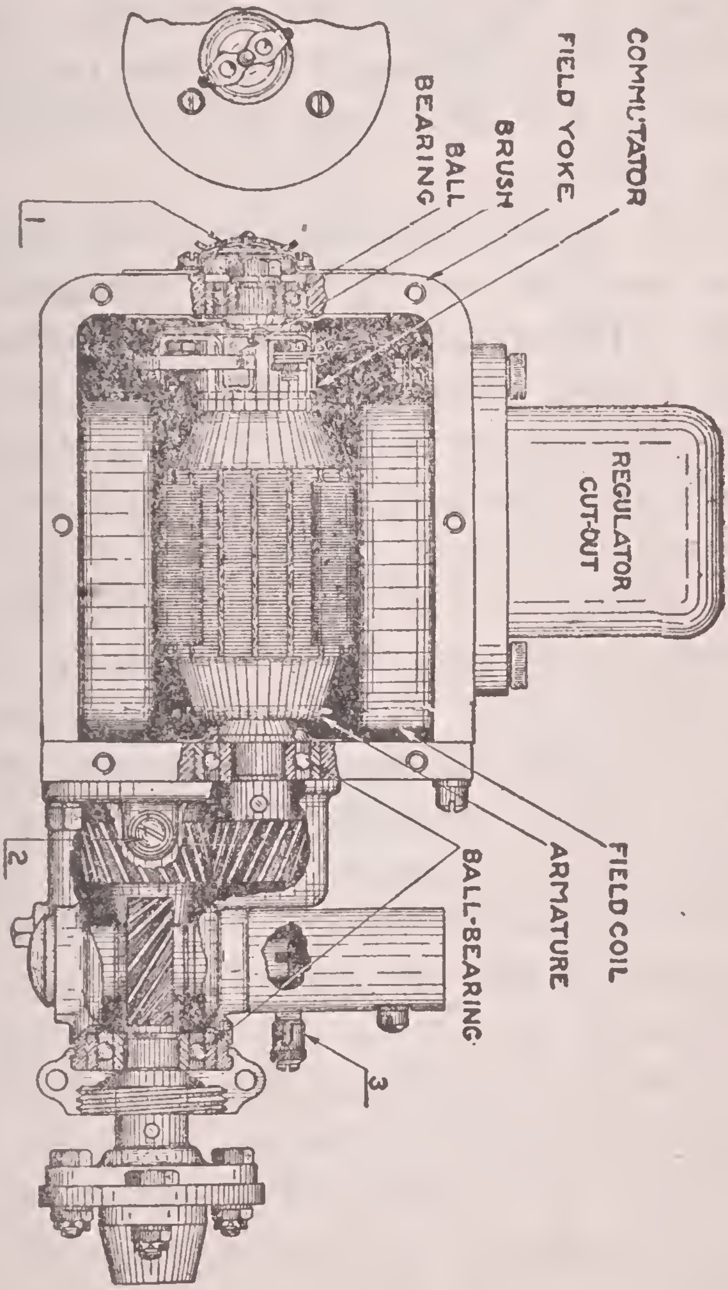


Fig. 291
Gray & Davis Dynamo With Vibrating Regulator
1, 2 and 3, Oil Holes

The wiring for this system is plainly shown in the accompanying diagram. See Fig. 289.

The newer models of Gray & Davis equipment make use of a separate dynamo or ignition-dynamo with a combined output regulator and cut-out carried in a housing on top of the unit. The interior construction of the dynamo is shown in Fig. 291, the particular model illustrated being arranged for carrying an ignition head at the drive end and providing a spiral gear drive.

The cut-out and regulator are in the same case and the one large electromagnet operates both. This magnet carries two windings, shunt and series. When the dynamo is idle the cut-out contacts are open and the two regulator contacts are closed, being held that way by their respective springs. Fig. 292. Current enters the shunt coil of the controller through the grounded end and down through the terminal A to the negative brush, thus receiving current from between the brushes whenever the dynamo runs. When the voltage rises to a point in this coil so that the magnet overcomes the tension of the cut-out spring the cut-out contacts close. Current which has passed from the grounded positive brush of the dynamo through the battery in charging, returns to the terminal B and passes through the entire length of the series coil on the magnet before going through the cut-out contacts to the terminal A and negative brush. Current which has passed through the lamps returns to the terminal L and through only a part of the series coil on the magnet

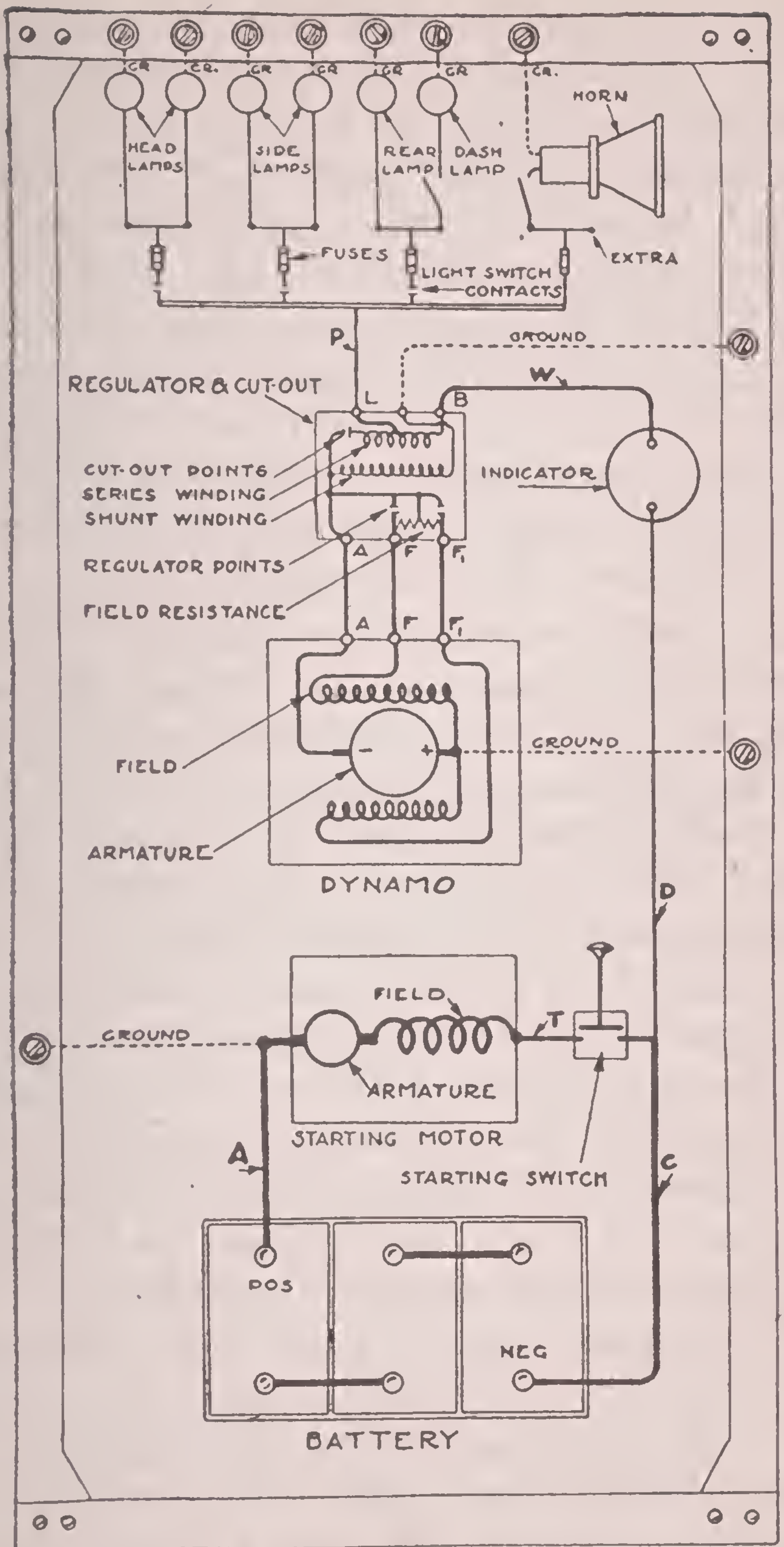


Fig. 292
Internal Connections of Gray & Davis Vibrating Regulator System

before reaching the negative side. The more lamps are turned on the more current they take and the less current is left to pass through the battery. It will therefore be seen that if enough lamps were turned on to leave nothing going through the battery the part of the series coil between L and B would carry no current and the strength of the magnet would be weakened. For the same reason it will be seen that the more lamps turned on the weaker this coil and magnet become. This is part of the regulator action as will be explained.

The regulator action is as follows: Current passes from the positive brush through the shunt field and into the terminals F and F1, then through the regulator contacts which are closed and back to the terminal A to the negative brush. As the voltage passing through the shunt magnet coil increases after the cut-out has closed, its strength finally reaches a point where the tension of the regulator contact spring is overcome and the contacts are pulled open. The current from terminals F and F1 must now return to the negative brush through the resistance wire coils seen between the two regulator contacts, this resistance retarding the flow and weakening the dynamo fields and consequently lowering the output and voltage until the weakened magnet allows the regulator contacts to again close. This action causes these contacts to vibrate and keep a steady output. As explained above, the strength of the magnet is decreased as more lamps are turned on, so that the regulator contacts remain closed for a longer time, and, as the resistance is not in the field when they are closed, the output is allowed to rise to care for the added lamp load.

The cut-out is of the simple electromagnetic type. The action of the regulator allows the battery to receive a small charge even with all lamps on.

Removable plates cover either side of the dynamo, allowing access to the inside without disturbing any parts or wires.

A charge indicator is located on the dash or cowl. The pointer turns upward if current is passing to the battery and downward when current passes out of the battery for any purpose. If the pointer is straight across the battery is neither charging or discharging. This indicator should show charge at car speeds above 10 to 12 miles per hour.

The output of the dynamo may be tested by turning on all lamps and disconnecting the wire from terminal B. The lamps are then burning directly from the dynamo and if they go out the dynamo is at fault.

The regulator and cut-out may be tested by connecting a wire from terminal A to terminal B while the engine runs at a speed which would correspond to a car speed greater than 10 miles per hour. If the indicator then shows charge when it failed to show this before the test the cut-out or regulator is at fault. If the indicator remains straight across something is preventing the dynamo from delivering its current.

The lighting switch is of the rotary snap type and carries all lamp and circuit wires on the engine side. On the back of the switch are four fuses in clips. Near the fuses are letters H, S, R and B, indicating the fuses for head, side or dimmer, rear and tail, ignition and horn circuits respectively.

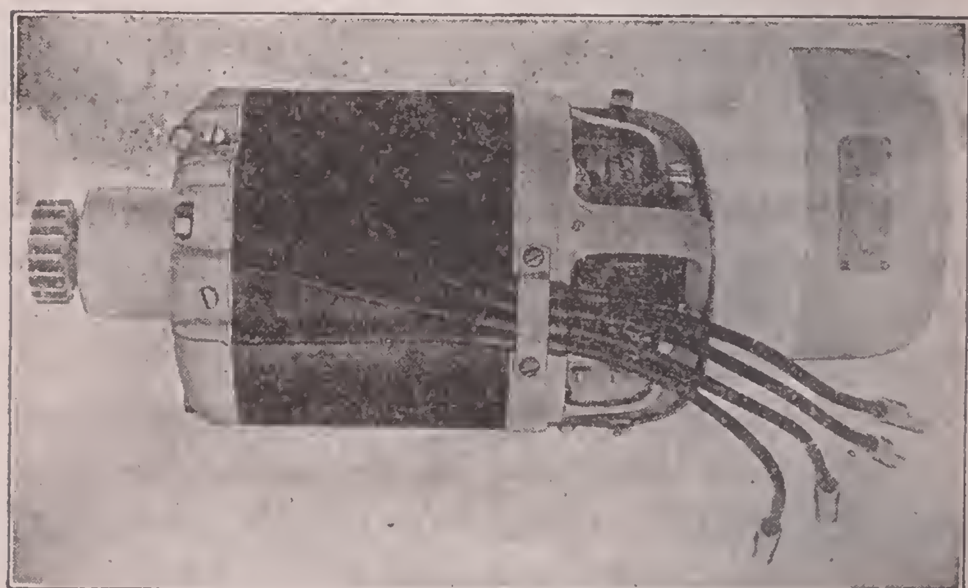


Fig. 293
North East Motor-Dynamo

The starting motor drives into a flywheel ring gear or crankshaft through sliding reduction gearing and overrunning clutch. The starting switch pull rod operates the sliding gear through a coil spring so that switch contacts may close whether gears are in position to mesh or not, the first turning of the armature causing the gears to snap into mesh under the action of the compressed spring. One side of the starting switch may be grounded or the lead from the positive motor brush may be grounded. In either case two wires lead to switch and starting motor.

North East Equipment. This starting and lighting system makes use of a combined motor-dynamo having two field windings, a shunt and series. The series field is used for starting and the two fields compound for generating. One of these units is shown in Fig. 293.

The brushes and commutator may be exposed by removing a cover from the end opposite the drive. The upper part of this cover, which encloses the brushes, is held in place by spring clips, but the lower half is fastened with bolts that are sealed at the factory. This lower half encloses a combined cut-out and regulator. The cut-out is of the electromagnetic type and serves to connect the dynamo with the battery when the generating voltage is sufficiently high to make charging possible, also to disconnect the battery when the dynamo voltage falls below that of the battery.

The regulator is of the vibrating reed type, having two sets of contacts operated from one electromagnet. The current output of the dynamo passes through the winding of the regulator electromagnet and causes the contact to open when the amperage has reached a certain predetermined limit. With the contacts open, the field current, which has previously passed through the contacts, must flow through two spools of resistance wire. The consequent reduction in field current prevents further rise in output.

North East equipment is of the two voltage type, the starting voltage being either 12, 16 or 24, while lighting and charging is accomplished at 6, 8 or 12 volts. Starting and charging circuits are of the two wire type, while lighting circuits may be either one wire with ground return or two wire throughout. A field fuse is carried in the brush and commutator compartment of the motor-dynamo, this fuse blowing out should the battery or charging lines become disconnected while the motor-dynamo is operating.

The unit is driven from the engine and drives to the engine through a silent chain, with or without spur gear reduction.

Remy Equipment. Remy apparatus consists of a variety of types, each one suited to the particular requirements of the cars to which it is applied. A complete internal circuit diagram of one of the separate unit systems with separately mounted regulator and cut-out is shown in Fig. 295.

Remy equipment may be made up of all separate units for lighting, starting and ignition, with or without Remy magneto or battery ignition. The separate unit systems all make use of a shunt wound dynamo of 6 volt output. The separate motors are of four pole, series wound type and operate on 6 volts.

A separate dynamo may be driven from a shaft to the timing gear case and have one of the separate motors mounted above it, forming a "double deck" instrument. The dynamo would be two pole shunt wound and the motor four pole series wound, both 6 volts. The motor drives down to the main shaft through two pair of spur reduction gears, the large gear on the main drive shaft carrying an overrunning clutch which runs free while the starting motor operates.

Another Remy system makes use of a motor dynamo with only one armature. This machine is of the four pole type, compound wound and operates with 12 volts. No overrunning clutch or device taking its place is used with the single armature motor dynamos, these being direct connected in all cases.

Remy dynamos are also built with a magneto type breaker mounted on one end of the armature shaft with a magneto distributer carried above it, thus forming a combined dynamo-ignition outfit. The dynamos in this case are of the two pole shunt wound type operating with 6 volts. These machines are positively driven at engine speed in four cylinder cars one and one-half times engine speed in six cylinder cars and twice engine speed in eights. A separate 6 volt starting motor is used in connection.

The 12 volt motor-generators (as described) are also built with the ignition breaker and distributer added, forming a single unit having the functions of starting motor, dynamo and igniter in one.

Wiring for lighting, charging and starting circuits may be either two wire or one wire with grounded return. Switches, current indicators, junction boxes and dimmer resistance units vary with the make of car.

Regulation of the amperage is accomplished in either of two ways. One method is by the third brush being below one of the main brushes on the left side facing the commutator. This brush takes current to one end of the shunt field winding, the amount of current flowing through this brush becoming less and less as the speed increases. The position of the brush is not adjustable.

The other method of regulation consists of an electromagnet carried in the same case with the cut-out and operating to insert a coil of resistance wire, also carried in this case, into the shunt field circuit as the amperage rises.

The cut-out is of the electromagnetic type with two windings, shunt and series. The circuit should close in the neighborhood of ten miles per hour, preferably at lower speeds. The cut-out mechanism or combination of cut-out

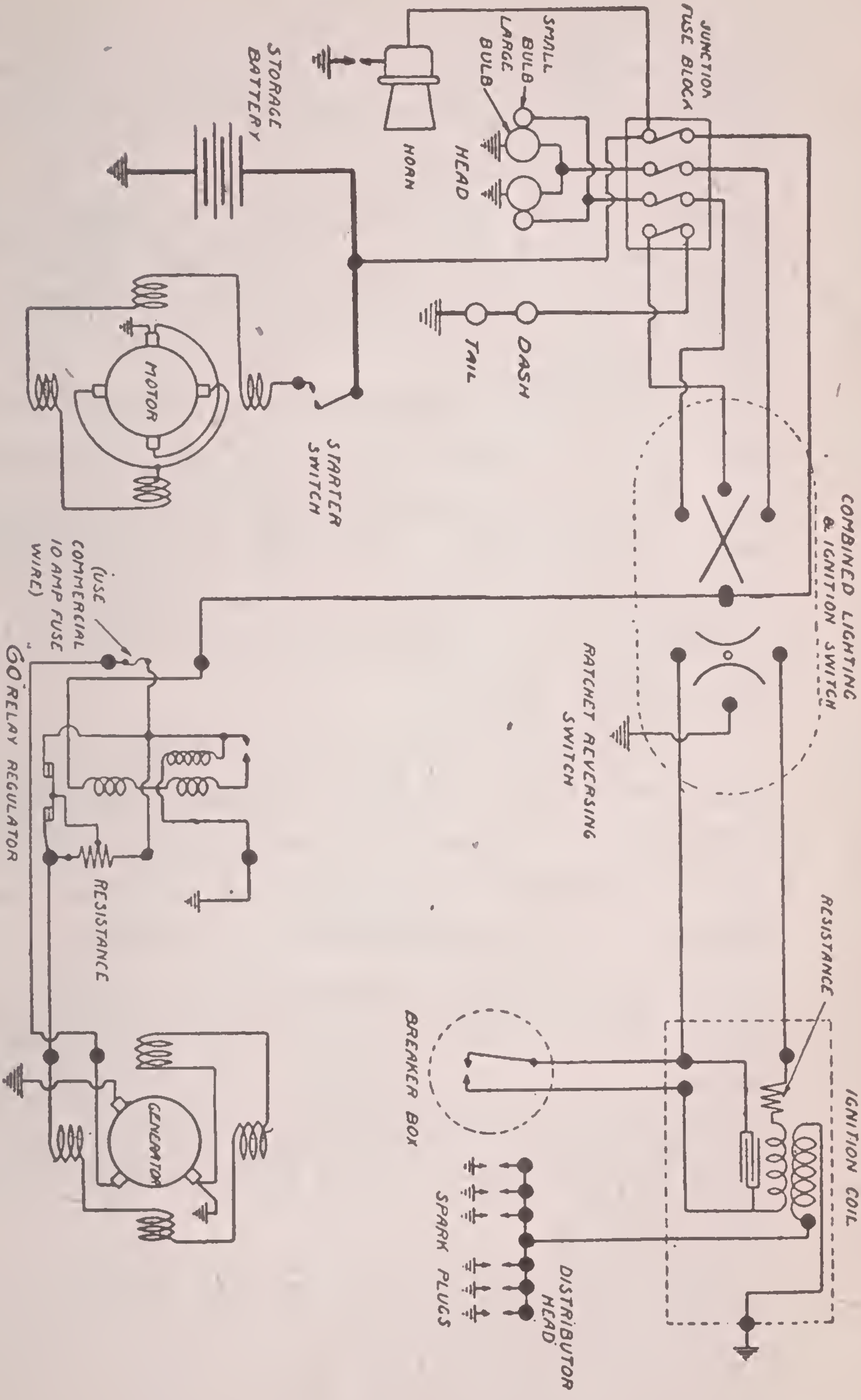


Fig. 294
Internal Connections of Remy System With Vibrating Regulator

and regulator may be mounted on the dynamo housing at the drive end over the armature shaft or as a separate unit on the dash or other convenient location.

The current output should be about 7 amperes at 8½ to 12 miles per hour, rising to a maximum of 10 to 14 amperes, depending on the installation.

Starting motor drive may be through reduction gearing inside the housing as described for the double deck instruments; or by chain with overrunning clutch on separate motors but without the clutch on motor-dynamos. Separate motors also use the Bendix type of inertia pinion drive.

Starting switches are of two types, both making the circuit complete without preliminary contacts. One uses the conventional type of tapered plunger, the other uses copper bands sliding on two cylinders, the cylinders being made of insulating material and carrying contact bands in such a position that the sliding rings complete the circuit from one cylinder to the other when fully depressed into position. Either switch may act by push or pull rods or foot buttons.

Fuses for each of the lighting lines are carried in the lighting switch. A 20 or 25 ampere fuse in circuit with the dynamo field is mounted above the magnet in separate cut-outs or on the base of combined regulators and cut-outs.

A number of models of Remy generators are built with a third brush type of regulation and have, in addition, a thermostatic control which is peculiar to these systems. The principle of this control is shown in Figure 295, the drawing at the upper left showing the thermostat with the contacts closed, the drawing at the lower left showing the contacts opened with the thermostat heated, while at the right is shown the

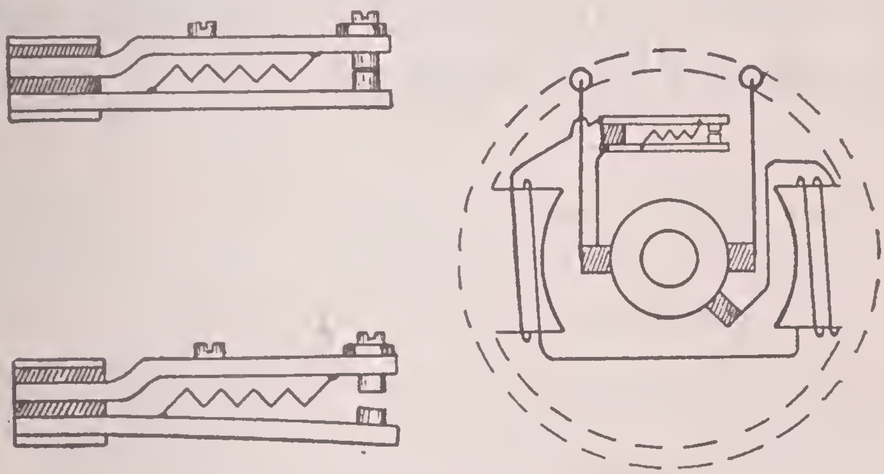


Fig. 295
Remy Thermostatic Control

connection of the device in the field circuit of the generator.

The thermostat is composed of a resistance unit, shown connected between the upper and lower parts, two silver contact points and a spring blade which carries one of the contact points. This blade is made of a strip of spring brass welded to a strip of nickel steel, a combination which will warp when heated, due to the greater expansion rate of the brass. At low temperatures the contacts are held together, but at approximately 175° Fahrenheit, the blade bends and separates the points.

When the thermostat contacts are closed, with the parts cold, the full field current from the third brush passes through them and permits full output from the generator. After the engine runs long enough for the parts to become heated, the opening of the contacts causes the field current to pass through the resistance with the result that the reduced flow cuts the charging rate to a lower amperage.

Rushmore Equipment. The Rushmore system was originally manufactured by the Rushmore Dynamo Works, but this company is now a part of the Bosch Magneto Company, and the product is known as "Bosch-Rushmore" and "Bosch." The several unique features found in this equipment are described on the following pages:

THE RUSHMORE ENGINE STARTER. The Rushmore electric starting motor, shown in Fig. 296, acts directly on the flywheel without intermediate gears, a pinion keyed fast on the motor shaft meshing with a gear on the flywheel rim. This pinion is normally out of engagement. The closing of the starting switch causes the pinion automatically to engage the flywheel gear before the armature starts rotating. As soon as the engine picks up, the pinion automatically slides out of mesh, and remains out no matter how long the starting switch is held closed. There is no mechanism except the starting motor itself and the starting switch.

When the starter is not in use the armature is held normally out of line endwise with the pole pieces by means of a compression spring contained in and acting against the hollow armature shaft. Magnetic pull is employed to engage the pinion. The foot button starting switch has three contacts. At the first pressure upon the button the armature is drawn into the field with great force while rotating slowly so that the pinion teeth will engage. After the gears are fully engaged the third contact applies the full force of the battery to turn over the engine.

The motor is series wound and produces a strong torque on starting. As soon as the en-

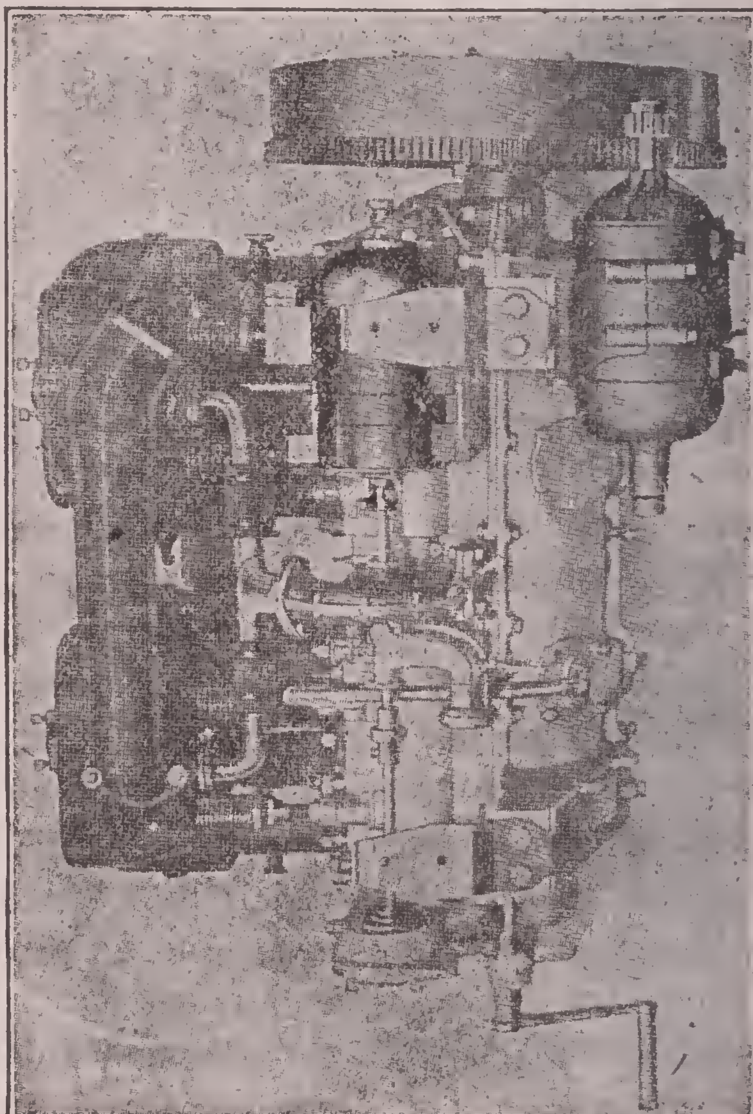


Fig. 296—Rushmore Dynamo and Starter on Simplex Engine.

gine picks up, the accelerated speed causes the counter electro-motive force in the motor to reduce the current flow to a value too small to hold the armature in line with the pole pieces against the end pressure of the spring. The pinion then slips out of mesh and remains out, even with the circuit closed, because the current required to run the motor free is too small to overcome the spring. The armature will not again move endwise into its working position until it has stopped and the switch is again closed. The turning force developed at the flywheel rim is rated at over 400 lbs., suffi-

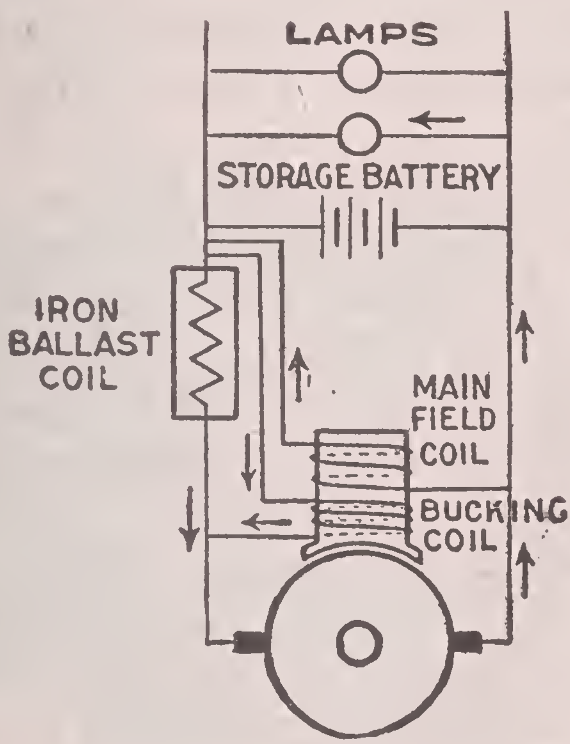


Fig. 297—Diagram of Rushmore Lighting System.

cient to start the largest engine with ease. The motor is wound for a 6-volt battery.

Rushmore Lighting System. Essential elements of this system are: 1, the dynamo; 2, storage battery, 6-volt, of 80 to 160 ampere hours capacity, depending upon size of the headlights; 3, switch and terminal block on dashboard, which simultaneously switches the headlights on or off and switches the ballast coil in or out of circuit; 4, wiring and circuit switches for small lamps.

Briefly the action of the dynamo is to reduce the strength of the field magnet at high speeds by means of counter excitation produced by a few turns of magnet wire, called a "bucking coil," on the field poles. The amount of current passing through this bucking coil is determined automatically by the varying resistance of a small coil of iron wire, called the "ballast coil," which is made in the form of a cartridge fuse and carried in clips on the switchblock in the main line between the dynamo and the battery. See Fig. 297. The effect of controlling the bucking coil by the current output is to produce an approximately constant current at the higher speeds.

Simms-Huff Equipment. This apparatus as generally mounted consists of a combined dynamo and motor with separate magneto ignition. One wire system with a grounded return for all circuits is used.

The motor dynamo is of the six pole type and has a differential compound winding. It generates 6 volts as a dynamo and operates with 12 volts as a motor. The drive for dynamo purposes is by belt from the fan pulley and crankshaft. When operated as a motor the engagement is through a pinion which slides on a counter shaft between the armature shaft and flywheel ring gear and completes the mechanical connection.

The starting switch which makes the necessary changes in connections for charging or starting is located on the transmission case and the operating parts also act to slide the gears into mesh through the action of a stiff coil spring. Should the gears not match exactly, the spring compresses and allows the switch to close when the first movement of the armature under the

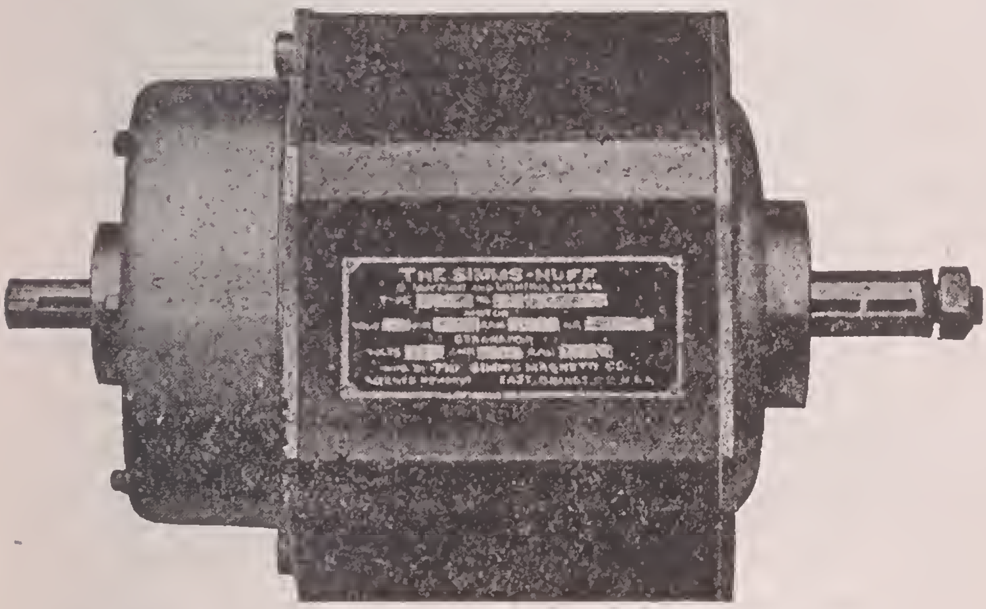


Fig. 298
Simms-Huff Motor Dynamo

starting current brings the gears into position and the compressed spring forces them into full engagement.

Regulation of output is maintained at a sufficiently high value (15 amperes maximum) by adjusting the tension of the driving belt. Excess-output is prevented by the differential action of the reversed series field winding and by a separate regulator having an electromagnet which acts to insert resistance in the shunt field winding with rise of amperage. This electromagnet regulator is carried in a housing with the cut-out. The output is adjustable by changing the tension of the flat spring.

The cut-out is of the electromagnetic type having two windings and the time of opening and closing is adjustable by a small screw.

Two 6 volt, 35 ampere hour batteries are carried in one box under the front seat, being connected in series for starting and parallel for lighting and charging. A combined lighting and ignition switch is carried; inserting the plug turns ignition on.

Headlight dimming resistance is carried on the engine side of the switch and an ammeter switch and an ammeter is mounted on the dash.

Splitdorf-Apelco Equipment. The electrical unit for these equipments is shown in Fig. 299, and its connections with the balance of the apparatus is shown in the wiring diagram, Fig. 300. The wiring shown applies to the equipment operating at 12 volts for starting and 6 volts for charging and lighting.

These systems use a combined motor dynamo which may also carry an ignition breaker and distributor on a separate vertical head driven from one end of the motor dynamo unit. The system is therefore of one or two unit type, no separate starting motors being used. A dynamo which does not act as a starting motor is used on the Stanley steam car. All gas cars use motor dynamos.

The unit has four poles, three windings on the fields. One coil is ordinary shunt and acts as

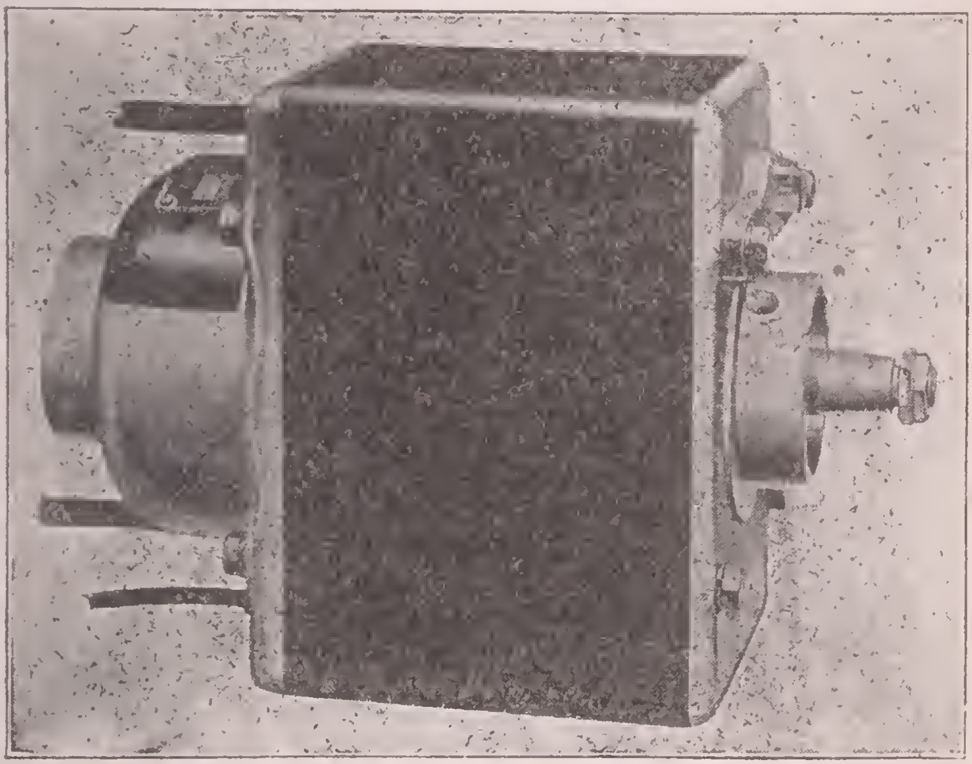


Fig. 299

Splitdorf-Apelco Motor-Dynamo

a shunt in both generating and starting. The output is controlled by a separate bucking coil through which all current from the dynamo passes, this opposing the shunt more and more as the speed, voltage and amperage increase. The third coil is a series winding for starting motor action, though it also assists the shunt while generating, making a compound dynamo with bucking coil and a compound motor.

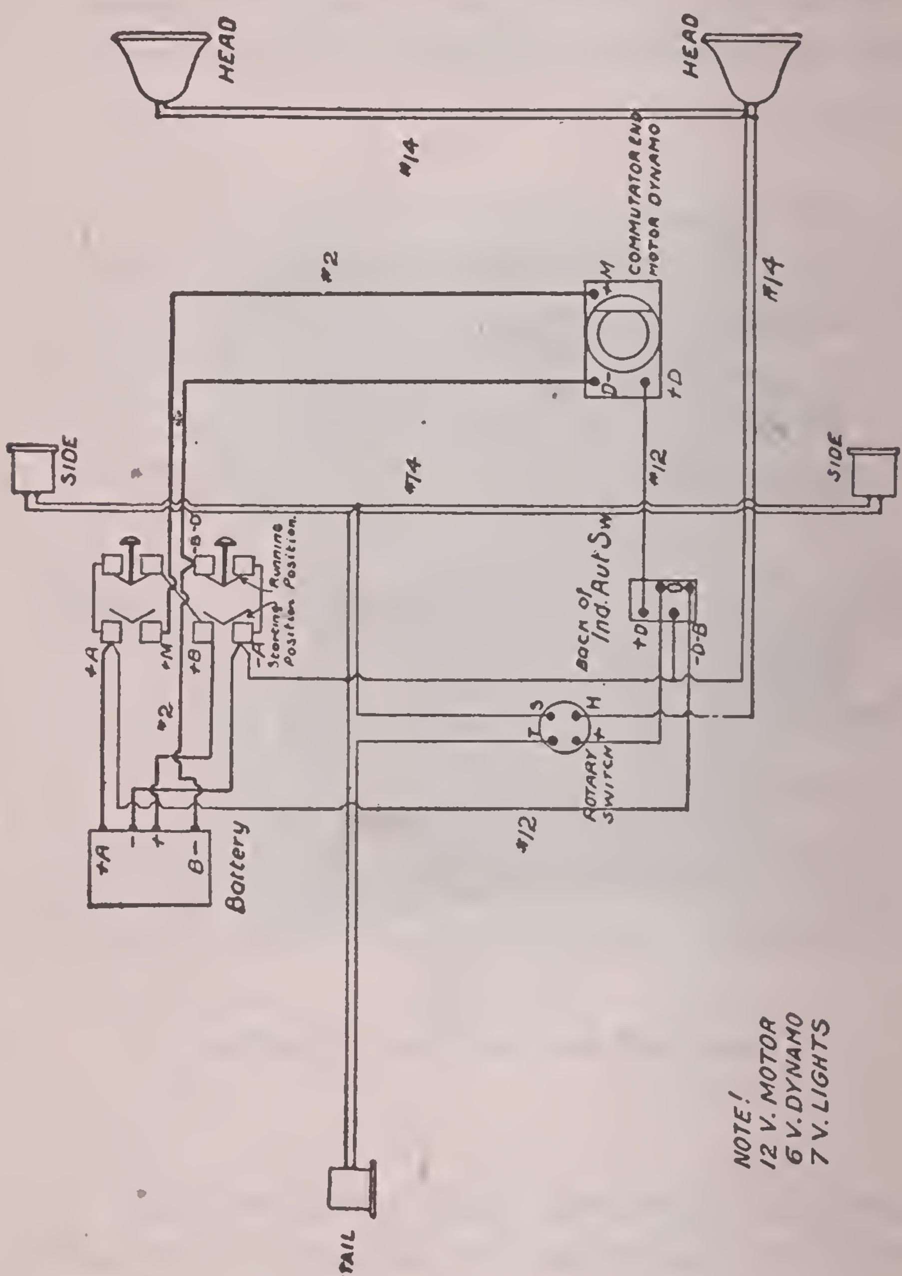


Fig. 300
Splitdorf-Apelco Wiring for 12-6 Volt System

Two voltage combinations are used. One charges the battery and starts on 12 volts, using a six cell battery with all cells in series for charging, starting and lighting. This is called the straight twelve system.

The other system uses a six cell battery divided in two sections of three cells each and is charged with the two parts in parallel at 6 volts. This system uses all cells in series with 12 volts for starting while lighting is from the parallel connections, thus giving 6 volt charging and lighting and 12 volt starting, the proper connections and changes being made in the starting switch. This is the twelve-six volt system.

Both types use separate electromagnetic cut-outs mounted on the dash in all cases. The cut-out carries two windings. The movable arm carries a marker which shows the word OFF on a dial whenever the contacts are open and the word ON whenever the contacts are closed. ON simply indicates that the current is flowing from the dynamo, but according to the number of lamps turned on it may be going to the battery or to the lamps or may be dividing between them. The engine speed at which the cut-out opens and closes may be changed by a small screw passing through the cut-out spring. This screw may be turned to either lessen or increase the spring tension, thus lowering the cut-in speed or raising it accordingly.

The dynamo without starter action is a four pole shunt wound machine operating at 6 volts. Regulation is with a third brush which carries all the current flowing to the shunt field.

U. S. L. Equipment. Two distinctly different types of equipment have been marketed by the United States Light and Heating Company. The first type, which is described first, was used up to and including part of the year 1915. This type comprises a motor-dynamo mounted on the engine crankshaft with the controlling elements, cut out and regulator, carried in a housing on the driver's side of the dash board.

The type referred to above is known as the "external regulator" type, while the newer system is the "inherently regulated" type. This newer system makes use of a cut out on the dash, but secures regulation of current output by allowing the dynamo current, when excessive, to react on part of the field, and by reducing the field magnetism in proportion to the speed and output, a proper rate of dynamo charge is maintained.

U. S. L. Electric Motor Generator. In the system employed by the United States Light & Heating Co., with which many automobiles are now equipped, an electric motor generator is an integral part of the gasoline motor and furnishes current for starting and lighting. The system includes, besides the motor generator, an automatic current regulator, an oil switch and a storage battery.

The motor generator comprises a set of field coils, armature and commutator and brush ring. These parts replace the flywheel of the gasoline motor, being attached to the crankshaft in its stead. They are inclosed in an aluminum case and dust ring.

When a starting button is pressed down, the current from the storage battery starts the

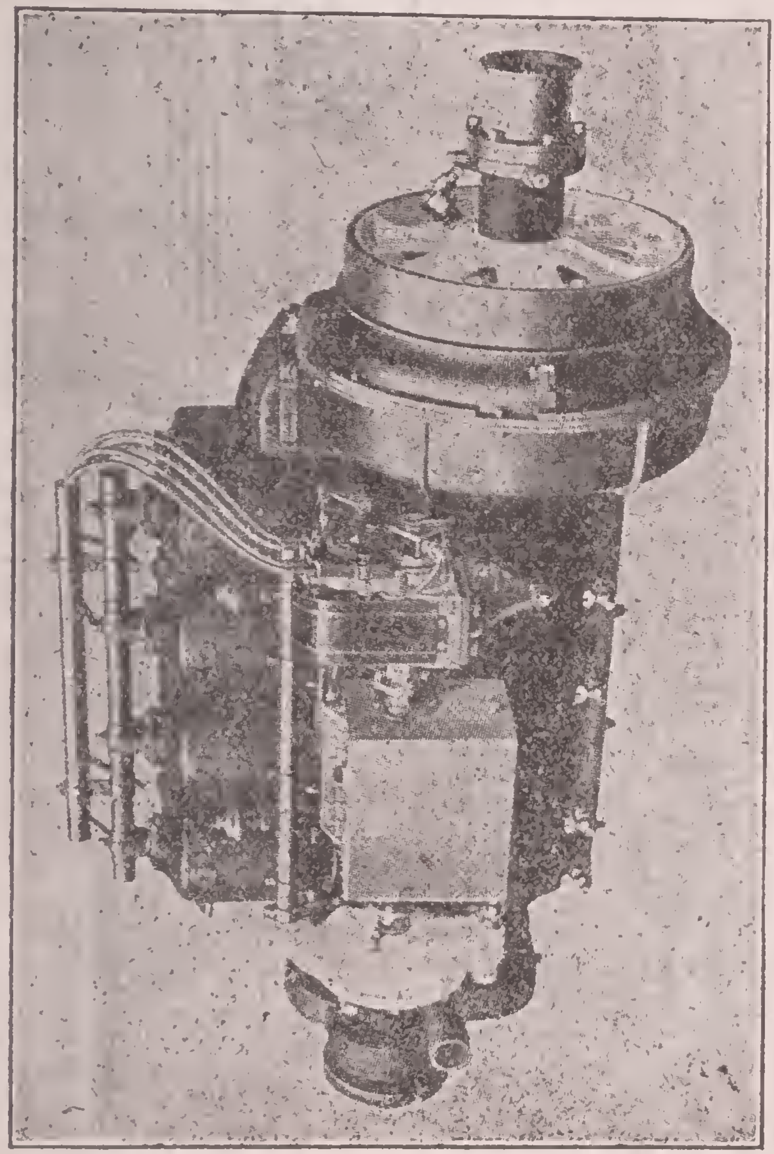


Fig. 301—U. S. L. Gasoline Electric Motor Complete.

motor generator. This revolves the crankshaft of the gasoline motor. With the switch of the ignition coil in either magneto or battery position, the gasoline explosions commence. The foot starting button is then released, when the

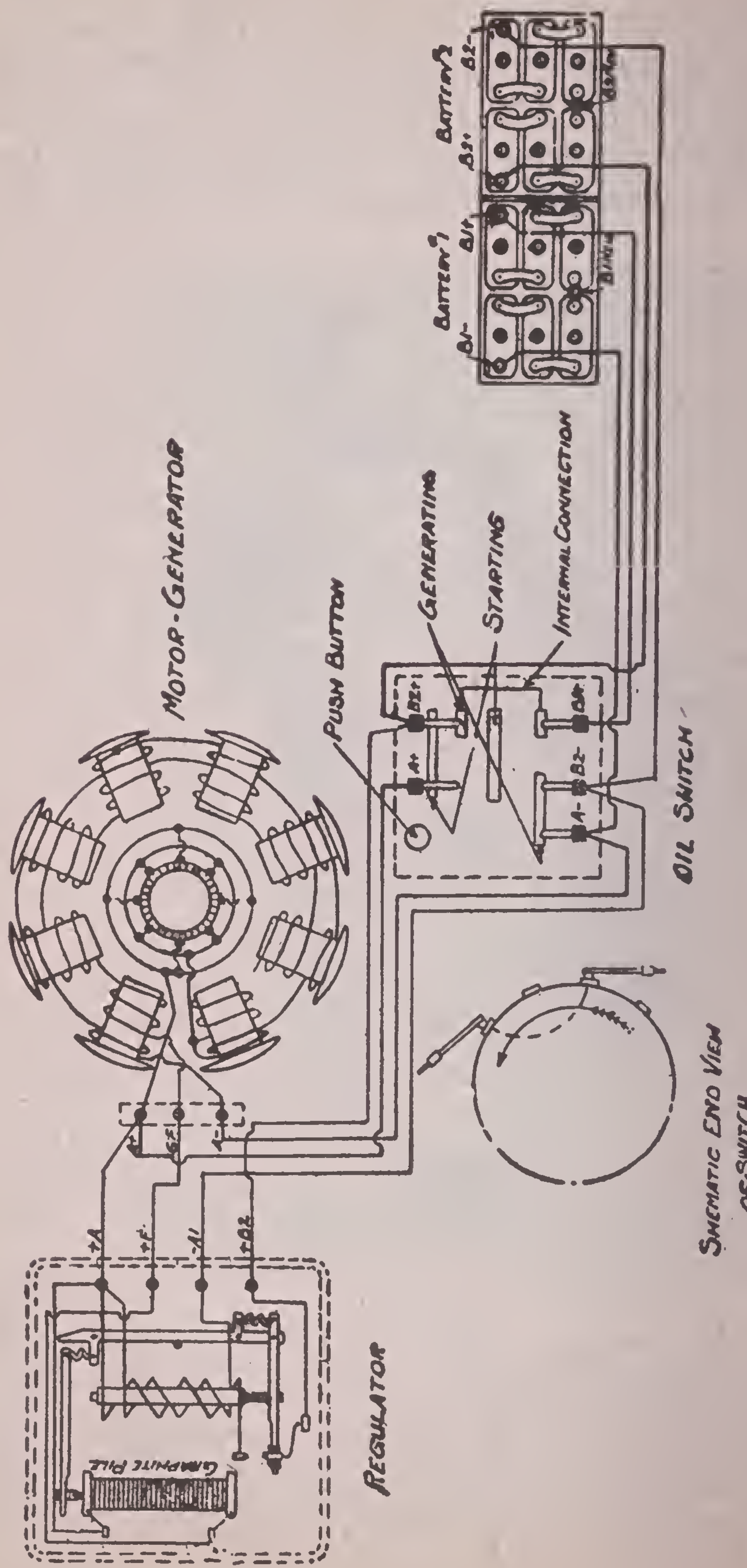


Fig. 302—Wiring Diagram of U. S. L. Starting System.

electric motor automatically changes into an electric generator. As the speed of the gasoline motor increases, the generator gradually begins charging the battery, restoring the current discharged during the starting operation.

An automatic regulator, controlling the current to the battery, is located in the center of the dash. It has a charging indicator, the function of which is to show that the circuit is closed at the proper time, or at a speed of 12 to 14 miles an hour, and that the circuit is open when the car speed drops below about 10 miles an hour or the motor stops altogether. The regulator consists of a compound-wound magnet and a variable resistance with magnet bar and contacts for controlling field current in the generator.

The oil switch is included in this system to change the electric motor into an electric generator upon the release of the starting button.

The type of U. S. L. equipment in most general use at present does not use the externally mounted combined cut-out and regulator but secures regulation of the output as a dynamo by means of a third brush system in which the flow of current through one of the field circuits depends on the current flowing into one of the brushes. The system is known as "Inherently Regulated." An electromagnetic cut-out is mounted on the dash of the car and serves the purpose of connecting the dynamo and battery when the dynamo voltage is sufficient for charging. The complete internal connections for this type of application are shown in Fig. 303.

Above the cut-out are carried two fuses, one of six empere capacity and one of 30 ampere. The six ampere fuse is in the field circuit and will blow out should the battery lines become disconnected with the dynamo operating. The thirty ampere fuse is in the main charging circuit.

The touring switch used with U. S. L. equipment may be opened when the car is used on long daylight runs, and by thus opening the field and charging circuit of the motor-dynamo, excessive battery charge is prevented. The two lamp combinations in use with this type are shown in Fig. 303; one of these being a three wire system with 7 volt lamps, and the other being the usual two wire system with 14 volt lamps. In either case, starting is accomplished with 24 volts and charging at 12 volts, the proper changes in connections being made in the starting switch.

The relative location of the parts of a U. S. L. system having inherent regulation and 12 volt pressure for all functions is shown in Fig. 304.

Wagner Equipment. Wagner apparatus may consist of a combined motor-dynamo with cut-out and starting switch mounted on the unit, or of separate motors and dynamos with a cut-out on the dynamo or mounted separately.

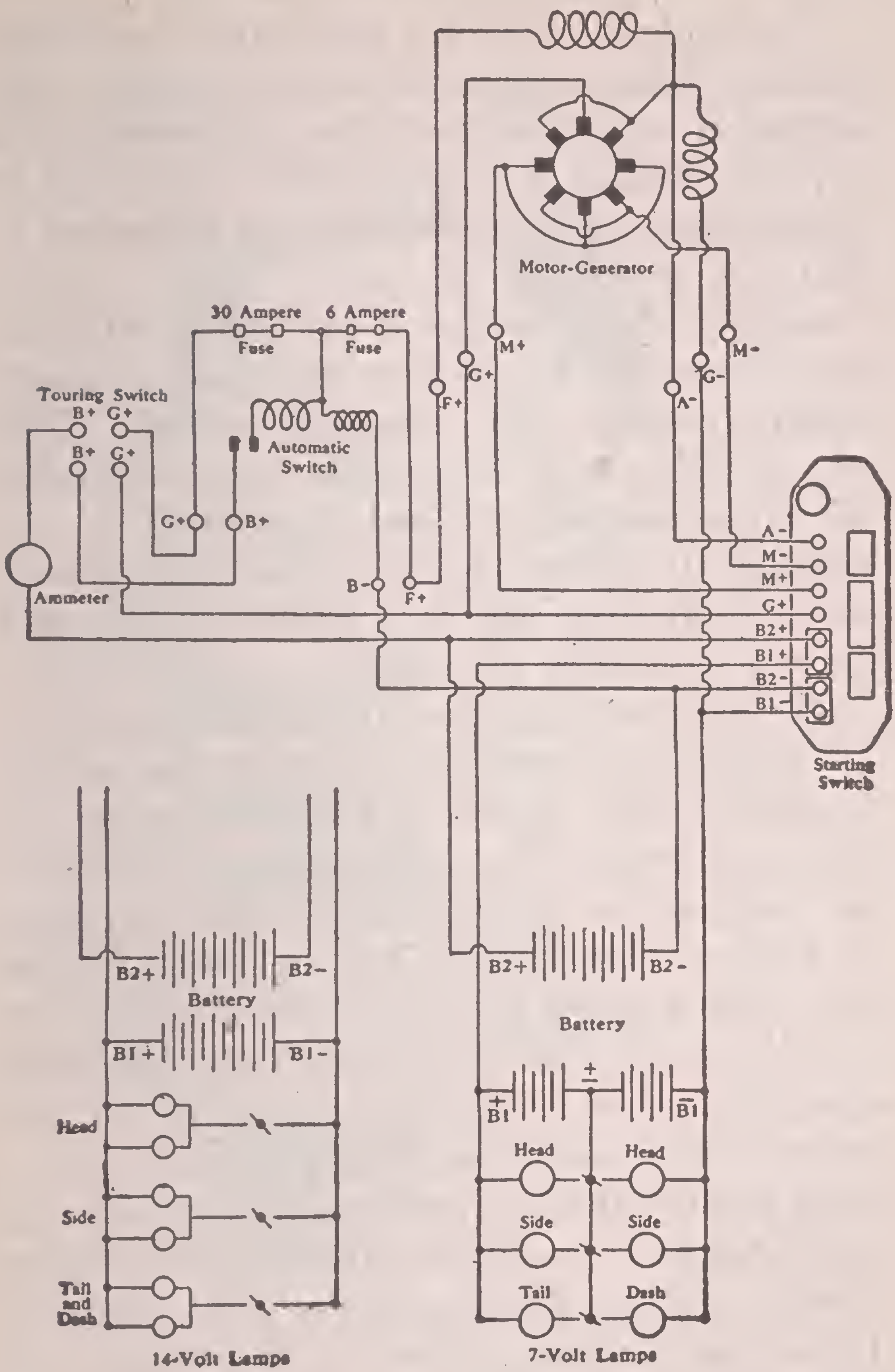


Fig. 303

Internal Connections of U. S. L. 24-12 **Volt Inherently** Regulated Motor-Dynamo System.

The motor-dynamo is a compound wound machine using the series fields for starting. The output is controlled by taking the shunt field current through a "third brush" which is so placed that excessive amperage is prevented at high engine speeds.

On top of the unit is a housing in which is an electromagnetic cut-out and also a rotary drum starting and charging switch. This switch makes such connections that starting is accomplished with 12 volts pressure by arranging all battery cells in series, while charging and lighting are at 6 volts with the two battery sections in parallel.

The motor-dynamo is driven from the engine by means of a chain to the front end of the crankshaft and is driven from the engine by this same chain. The necessary gear reduction for starting is secured through a planetary form of gearing carried in a housing ahead of the unit, this gearing being brought into play by a brake band that is tightened by the same operation with which the driver moves the rotary switch to the starting position.

If the dynamo, motor and ignition are all separate, the dynamo is shunt wound. Four brushes bear on the commutator, two receiving the main charging current. The other two brushes are slightly nearer together. The second pair of brushes carries the current to the shunt field and because of their location with reference to each other act to decrease the current flowing to the field at high speeds because of the distortion of the path of the magnetism

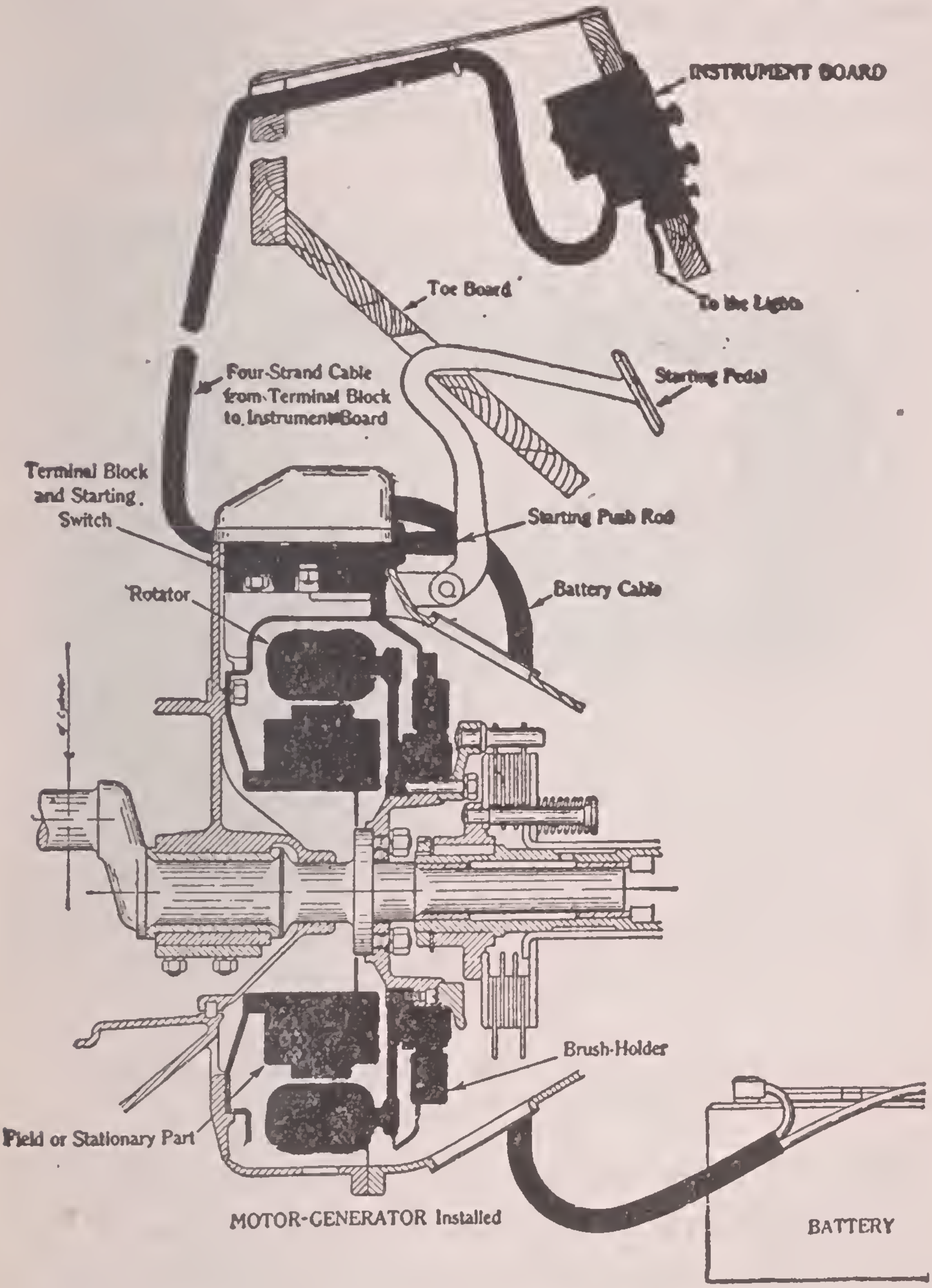


Fig. 304
Arrangement of Parts in U. S. L. Motor-Dynamo System

between the field poles. This regulation action prevents excessive charging rates at high speeds and causes the output to be slightly decreased at these speeds. The action of this form of regulation is also to increase the output with the increase in battery voltage so that the flow is greater to a battery when nearly charged than when nearly empty.

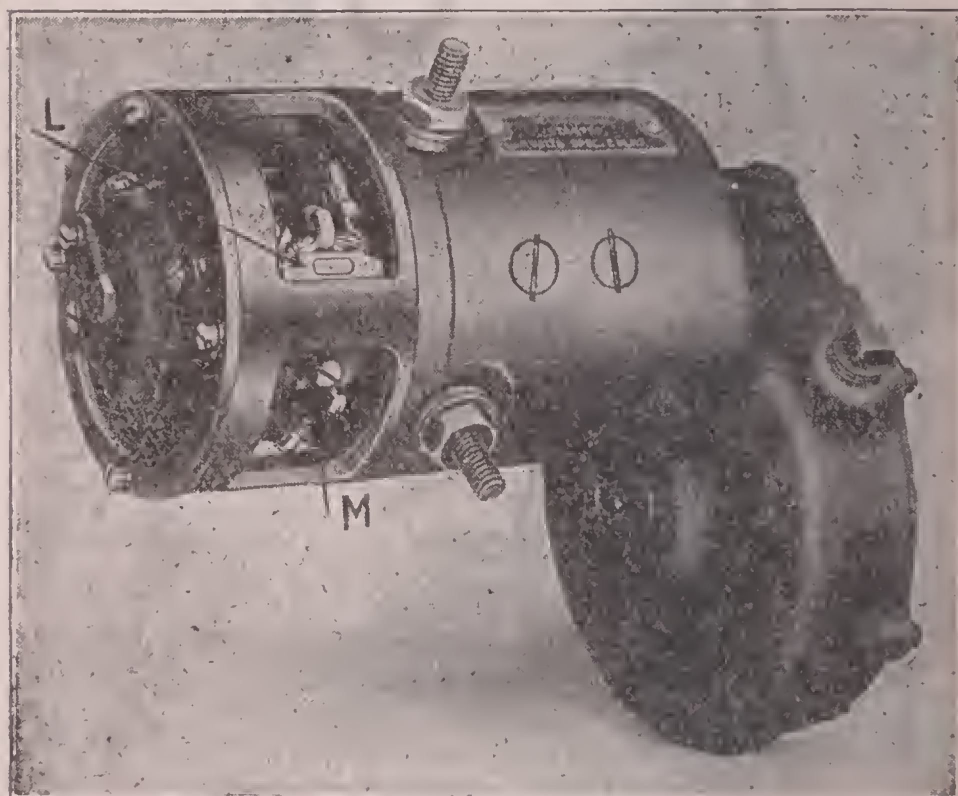


Fig. 305
Wagner Starting Motor With Gear Reduction
L and M, Brush Holders

The starting motor, Fig. 305, drives through a spur gear reduction and chain to the front end of the crankshaft. An overrunning clutch is built into the sprocket on the crankshaft. The starting switch makes the circuit complete without any preliminary resistance, the clutch providing the engagement.

Westinghouse Equipment. Three distinct types of Westinghouse apparatus are in use. The first, and oldest, type makes use of a separate dynamo securing output regulation by means of a bucking coil field as described in the following pages, and having an electromagnetic cut-out mounted on the dynamo. Another type includes a separately mounted dynamo having a vibrating reed voltage regulator and an electromagnetic cut-out mounted on the dash board or inside of the dynamo housing. The third type consists of a combined motor-dynamo having third brush regulation.

In generating current the machine acts as a shunt wound dynamo, the reversed series coil acting to regulate the amperage in a way peculiar to these systems. One end of the reversed series coil is connected to one of the dynamo brushes in such a way that current flowing into the battery for charging passes through this coil and by opposing the shunt winding keeps the amperage down to a proper point. The line which leads to the lamps from both battery and dynamo is attached to a lead from the differential winding in such a way that current from the dynamo to the lamps does not pass through the bucking coil. That means that the amount of current which flows through the bucking coil with the lamps off is the entire amount from the dynamo going to the battery, but as soon as the lamps are turned on a part of this current passes to the lighting lines and no longer goes through the bucking coil. The reduced flow through the bucking coil with lamps on allows the shunt field to exert its effect without so much opposition and the output accordingly rises to care for the additional lamp load. Should enough lamps be turned on to take the entire dynamo current, none will be left to the bucking coil and the dynamo will act as a shunt machine without opposition and give the fullest current flow of which it is capable under these conditions. Should still more lamps be turned on the additional current will flow to the lamp lines from the battery through the differential wind-

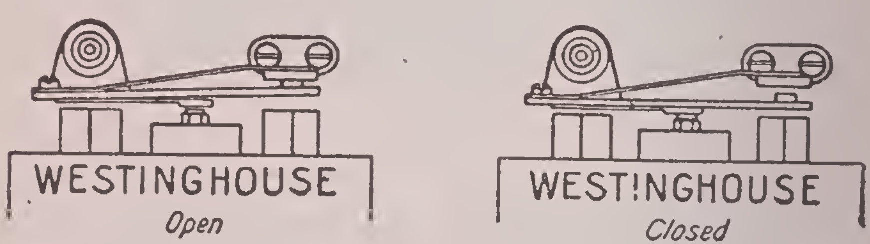


Fig. 306
Westinghouse Cut-out Used With Inherently Regulated Dynamos

ing, but in an opposite direction from which it passed in bucking the shunt action and will therefore serve as an additional series winding assisting the shunt and the machine is therefore compound under these conditions and the output is still further increased.

All dynamos of this type carry an electromagnetic cut-out, Fig. 306, on the dynamo housing at the drive end just above the shaft, the magnet carrying two windings as is the usual practice. This cut-out should close at about 8 miles per hour and re-open at about 6 miles per hour. It has no means of regulating the time of opening and closing. The wiring for this system is shown in Fig. 307.

The dynamo having voltage regulation is of the shunt wound type and the regulator acts to insert a resistance in the field when the terminal voltage rises to the predetermined limit. The operating parts of the combined cut-out and regulator are shown with the cut-out open in Fig. 308, and with the cut-out closed in Fig. 309. The complete internal connections of the voltage control dynamo with self contained regulator and cut-out are shown in Fig. 310.

When the dynamo is being operated at a speed below the predetermined "cut-in speed", the contacts of the cut-out armature are open, the voltage of the dynamo being below that of the battery. When the speed reaches the "cut-in speed" these contacts are closed, connecting the dynamo circuit to the battery circuit. The "cut-in speed" varies from five to ten miles per hour on high gear, depending upon the gear ratio and wheel diameter of the particular car.

The "cut-in speed" can be observed by running the car, allowing it to increase in speed slowly, and observing on the speedometer the speed at which the car is running when the cut-out contacts close, which is indicated by a slight movement of the meter needle.

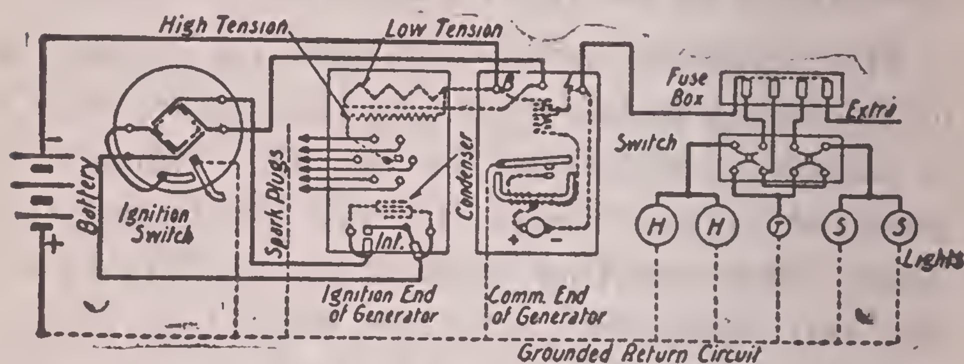


Fig. 307
Wiring of Westinghouse Ignition and Lighting System, Inherently Regulated

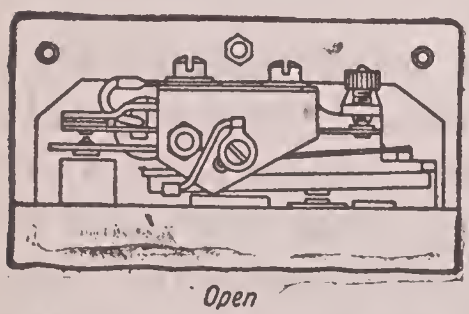
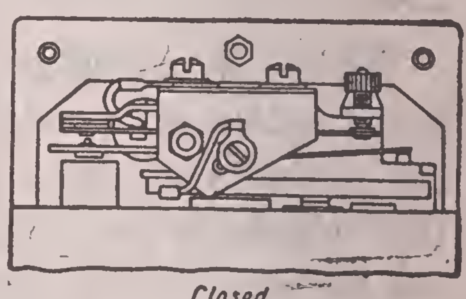


Fig. 308
Westinghouse Voltage Controller, Cut-out Open



Fige. 309
Westinghouse Voltage Controller, Cut-out Closed

The regulator is so constructed that the cut-out operates to disconnect the dynamo from the battery circuit at a speed slightly below the "cut-in speed". This enables the cut-out to keep the circuit closed, and not constantly open or close it when the car is being run at speeds

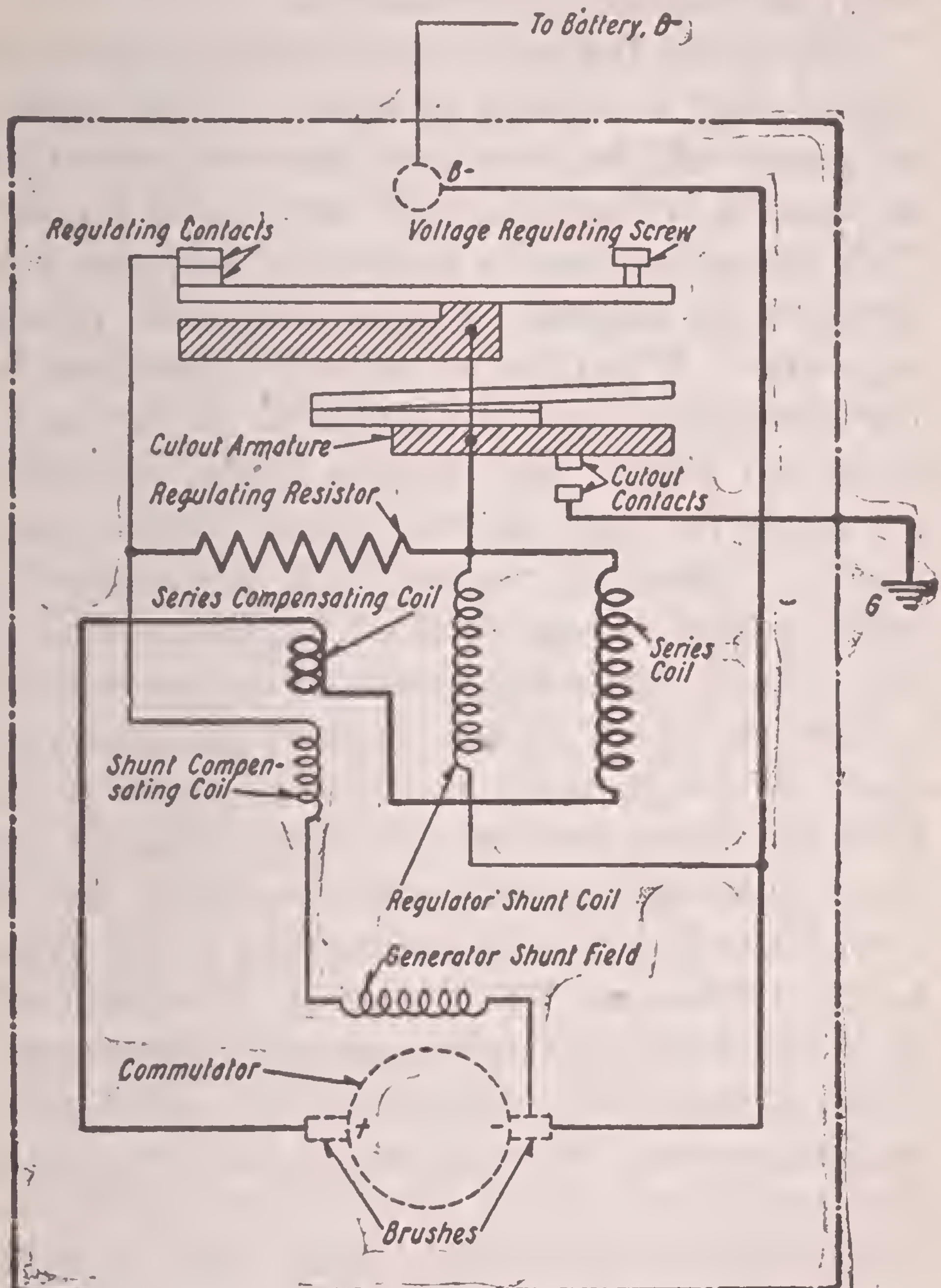


Fig. 310
Internal Connections of Westinghouse Self-Contained Voltage Control Dynamo

close to "cut-in speed". This disconnecting of the dynamo from the battery circuit when the dynamo voltage is below the battery voltage insures that the battery will not be discharged through the generator.

The shunt fields of the dynamo are so designed that a voltage in excess of the normal voltage would be regularly generated when the dynamo is operated at high speed and no load. This excess voltage is prevented and the voltage is held constant by the automatic voltage regulator. When the dynamo is operating below "cut-in speed" the contacts of this regulator are closed, and remain closed until the armature is revolved at a speed which generates a voltage in excess of a predetermined value. This voltage is fixed by the setting of the voltage regulating screw which is adjusted at the factory. When, due to the increased speed of the dynamo, the voltage tends to exceed the value for which the regulator is set, the regulating contacts open, opening the direct shunt-field circuit and cutting in the regulating resistance. This causes a momentary drop in voltage so that the contacts close again. This opening and closing of the contacts is continuous, and so rapid as to be imperceptible to the eye.

Dynamos are also furnished with ignition parts carried on one end of the dynamo frame, these parts consisting of a magneto type breaker which automatically advances the spark by a pair of governor weights acting as the breaker cams and a distributor mounted above the breaker. Otherwise the unit is the same as the dynamos described.

The combined motor dynamos are four pole compound wound machines operating with 12 volts, while the electromagnetic cut-out may or may not be employed. When the cut-out is used it is carried as a separate unit. These machines drive to the crankshaft direct through chains or gears without the use of overrunning clutches.

Almost all Westinghouse installations use the single wire system with the positive side of the circuit grounded in all cases. The ground return for the starting motor is assisted by having the cable enclosed in copper tubing which is attached to the metal work of the car and which is therefore free to carry the current to the motor.

The lighting switch is usually of the push button type. All circuits are fused, the cartridge fuses being carried in fuse boxes which provide for 3, 4 or 5 circuits in addition to the line to the battery. The fuse for head and tail lamps should be 15 ampere, for side and tail 5 ampere, for tail alone 3 ampere and for additional circuits such as the horn 15 ampere. When 6 volt bulbs are used with short wiring one of the fuses is replaced with a coil of resistance wire so that the voltage to the lamps with short connections may not be excessive. With 7 volt bulbs this compensator coil is unnecessary. Head lamps may be dimmed by throwing them in series or by arranging a restance coil in one lead to the lamps. Junction boxes are used to centralize the connections and disconnector blocks are used for allowing body removal. Either an ammeter or voltmeter may be used, the ammeter being connected on one of the battery lines to the lamps and dynamo in the usual way while the voltmeter is directly connected to the two sides of the battery, indicating the voltage at all times. The current drawn by the voltmeter is so small that it can be neglected in every way.

Separate starting motors are of the four pole type, series wound with the field coils carried on two of the four poles, and operate with 6 volts.

Starting motors may drive the engine in any of five different ways. One system drives from a pinion on the armature shaft to a larger spur gear on a counter shaft, this larger gear having an overrunning clutch built into it. Mounted on the counter shaft is a small pinion which is free to slide on the counter shaft until it meshes with teeth on the flywheel rim. This sliding pinion is moved by a yoke and rods from the foot pedal, these operating rods also operating the switch. The first movement of the pedal closes the circuit through preliminary contacts and resistance ribbon, causing the starting motor to whirl with little power. Further movement of the pedal breaks this electrical connection but leaves the motor spinning while the movement pulls the gears in mesh. After the gears are meshed the switch has traveled to a position in which full contact is made and the motor turns the engine. Releasing the pedal opens the switch and the gears are thrown out of mesh by a coil spring in the gear housing.

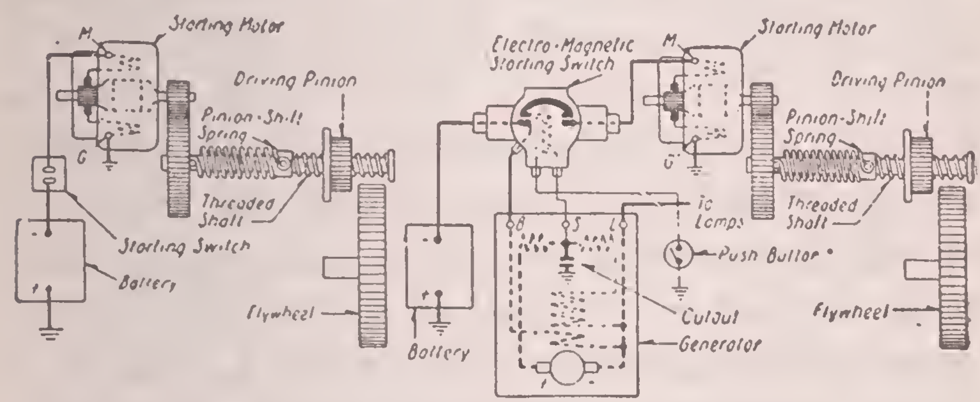


Fig. 311

Internal Connections of Westinghouse Magnetic Pinion Shift Starting Motor Drive

Another system uses the same arrangement of gearing between armature shaft and flywheel teeth but the gear meshing and closing of the switch is accomplished by solenoid action in place of by foot power. Three switches are used, Fig. 311, one being a push button on the dash marked "start," another being a small cylindrical housing through which the large starting cable runs and to which the wire from the dash button also leads and the third being the starting switch which is connected to the shifting pinion as previously described.

Pressing the dash button allows current to flow from the battery to the small cylinder-shaped switch and through the windings of a magnet on this switch. This magnet pulls the contacts closed which allow the battery current to pass through and to the large starting switch. The large switch contains a powerful solenoid coil through which the current then flows and out through a small auxiliary wire to the ground. The solenoid immediately pulls on a plunger which is attached to the sliding gear and starting switch contacts and the action of closing the contacts and sliding the pinion into mesh is done by the pull of the solenoid in the same way as previously described for the foot button action. As soon as the engine starts it runs the dynamo and the voltage of the dynamo rises to a point equal to the battery voltage. This balance of pressure prevents any more current from flowing through the switch operated from the dash button and the main starting cable contacts open whether the dash button is released or not. This kills the solenoid action and all parts return to normal positions.

The starting motor may also drive to the crankshaft through gearing or chains with overrunning clutch in which case the starting switch makes full contact in the first position.

Some installations drive to the flywheel by means of a Bendix type of application.

Steel. Steel is composed of extremely minute particles of iron and carbon which form a network of layers and bands. The carbon content of the steel is generally specified according to "points," a point being one one-hundredth part of one percent of the weight of the metal. A 40 point steel therefore contains 40/100 or 2/5 of one percent carbon. The greater the amount of carbon the harder and more brittle will the metal become.

Other elements commonly found in steel include the following: Silicon, which increases the hardness, brittleness, strength and difficulty of working. Phosphorus, which hardens and weakens the metal, but which makes it easier to cast. Sulphur, which tends to make the metal hard and porous. Manganese, which makes the steel hard and tough and of great tensile strength. Aluminum, which in small quantities helps to prevent blowholes. Chromium, which increases the strength; this element being often combined with nickel as an alloy. Tungsten increases the hardness without making the metal brittle. Vanadium increases the elastic limit, making the steel stronger and tougher.

Steel is made from cast iron either by the crucible, the Bessemer or the open hearth process. Steel may have a tensile strength varying from 50,000 to 300,000 pounds per square inch, depending on the carbon, other alloys and heat treatment.

Steering Gear—Principles of. In steering gears the generally accepted principle is that known as the Ackermann-Jeantaud, which was invented in 1878 and is a modification of the

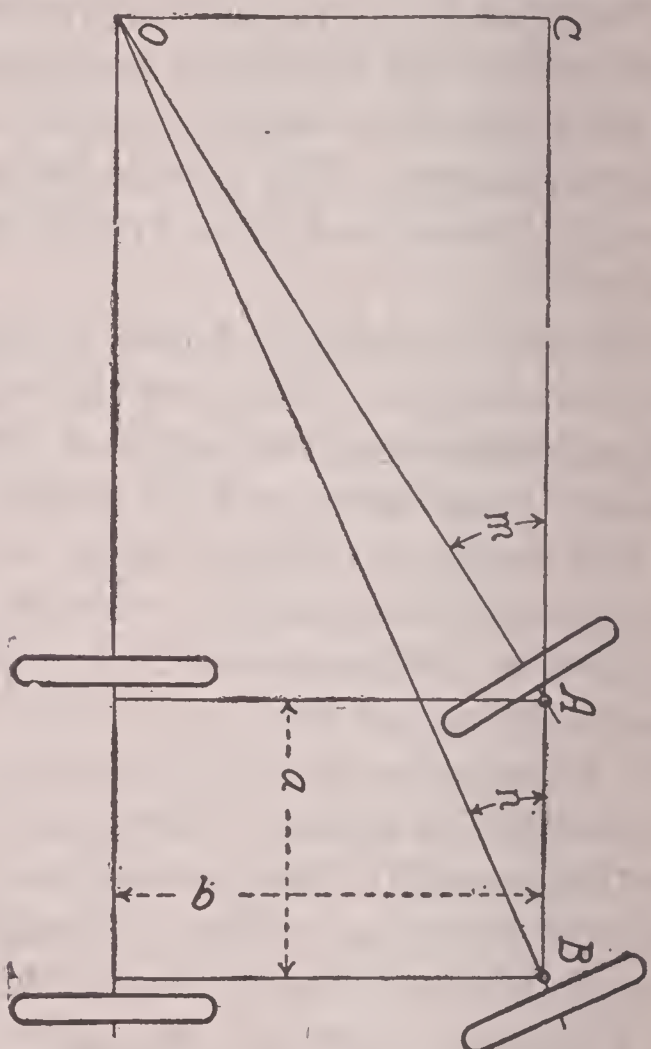


Fig. 312
Designing Steering Knuckle Arms

original Ackermann principle. In the Ackermann-Jeantaud system the steering knuckle arms OL and O[1]L, when produced, meet in the plane of the rear axle or in this plane produced as shown by illustration, Fig. 313. The reader will appreciate that when the tie-rod L L is in rear of the front axle, the steering knuckle arms, OL and O¹L converge, as illustrated, but should the tie-rod be in front of the axle, these arms diverge. Strictly speaking, the points A and AI, which are supposed to be in the axle

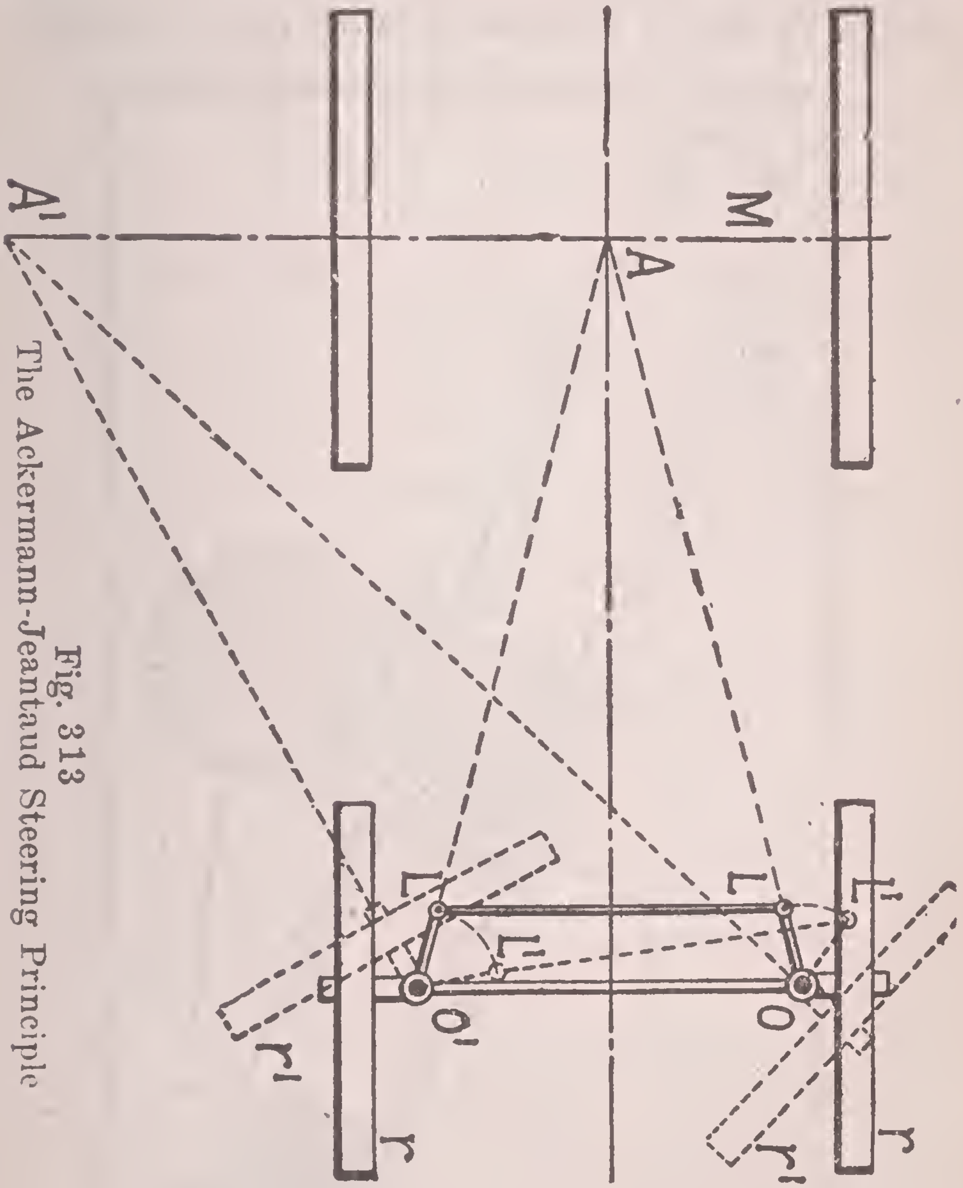


Fig. 313
The Ackermann-Jeantaud Steering Principle

plane, are not so, and the axle line A, AI, is a tangent to the curve in which the points of convergence will fall in a complete sweep of the steering wheels from axle to axle.

It will be realized from the foregoing explanation that the dimensions and proportions of the steering axle parts depend on the wheelbase of the car, inasmuch as with a longer wheel base the distance that the lines would be produced would be greater with the increase.

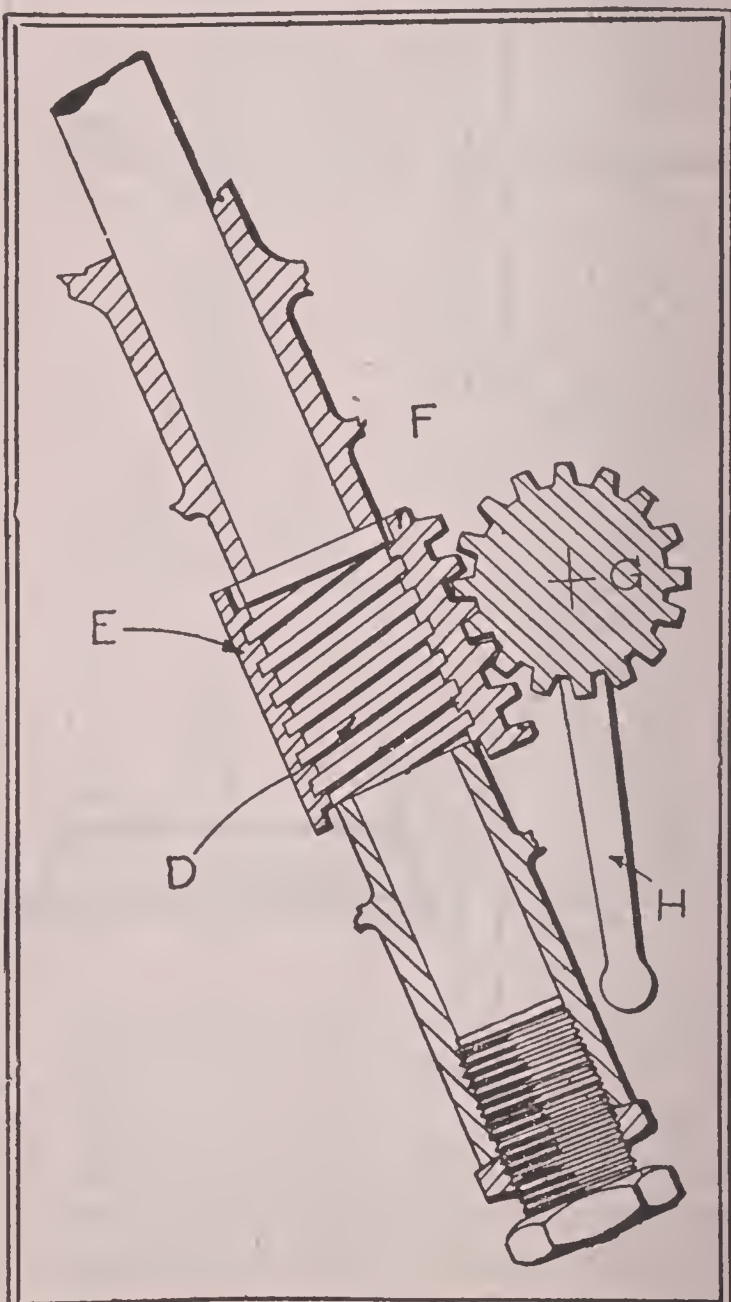


Fig. 314

Several makers have, however, discontinued the design of steering knuckles on this principle, preferring to design them as illustrated in Fig. 312, in which the produced axis of the front wheels, A and B, intersect the axis of the rear wheel at a given point O. With this condition fulfilled, the vehicle will travel around O as an imaginary center. Enthusiasts of this method of construction agree that the Ackermann-Jeantaud principle is sufficiently accurate for angles of not more than 30 degrees, but for angles varying from 30 to 45 they claim less wear on their tires by the latter construction. The exact arm for the angles in a steering gear of this nature will depend largely on the wheelbase of the car as well as the difference between the steering pivots A and B.

STEERING GEAR—TYPES OF. Fig. 314 shows a sectional view of the nut and segment type of steering gear, in which there is a worm D on the steering column that engages with the nut E. On the front or gear face of the nut is a rack F which meshes with the sector G, so that as the steering wheel is turned right or left the nut is raised or lowered and the requisite movement imparted to the radius rod H. In certain screw and nut steering gears the sector is not required, the construction being a screw on the steering column on which works the internally threaded nut, and on either side of this nut are trunnions with links which connect with the axis carrying the radius arm.

STEERING GEAR—LOST MOTION IN. If the gear is of the worm and sector type it may be that these two elements are not held in the proper relation to each other. Fig. 315 shows a diagram of this type of gear, and illustrates plainly the point where lost motion will be of the greatest detriment. When the wheel is turned, if there is the slightest end play, the wheel shaft

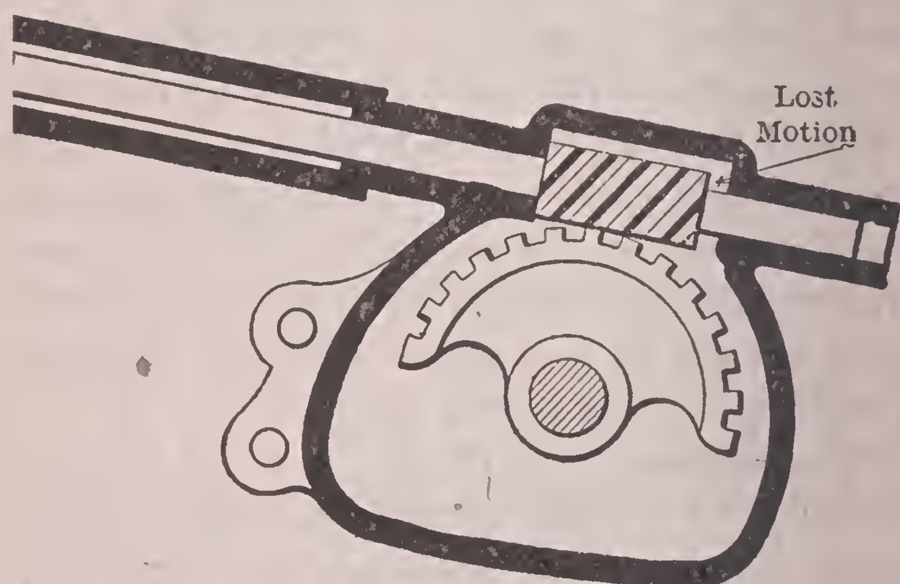


Fig. 315

will respond, but the geared sector will not, until all the end play is taken up, and as strains come on from the road wheels, the sector will rotate to and fro, causing the shaft of the steering wheel to reciprocate and thus allow the road wheels to wobble. To overcome this it is necessary to replace the thrust washer, if there be one, and if necessary, introduce a washer, made of phosphor bronze, of suitable thickness to take up all the end play of the steering wheel shaft.

Some lost motion will follow if the worm is not set on the pitch line, in its proper relation to the sector; this will be true if the bushings are worn, and when a new thrust washer is made and fitted into place, if the lost motion is still greater than is desired, the only thing remaining is to replace the bearing brasses. When the gear is dissembled it will be possible to dimension the same, and determine by measurement if there is any great amount of journal wear, thus rendering the task less troublesome, since the brasses may be replaced without waiting to determine the remaining lost motion through actual trial.

As a rule, it will be found that the lost motion is due to end play, just as the illustration shows, and not to worn-out journal brasses on which the wear is far less than it is in thrust. If the gear is irreversible, or nearly so, as it is in many automobiles, a little lost motion is to be expected owing to the smallness of the angle of the worm, which can only be irreversible if the angle is such that a little lost motion will be present and unavoidable.

Care of Steering Gear. The steering gear is a very important part of the car, and, as the safety of the occupants may be endangered by any binding, the autoist should give it even more careful attention than the other parts.

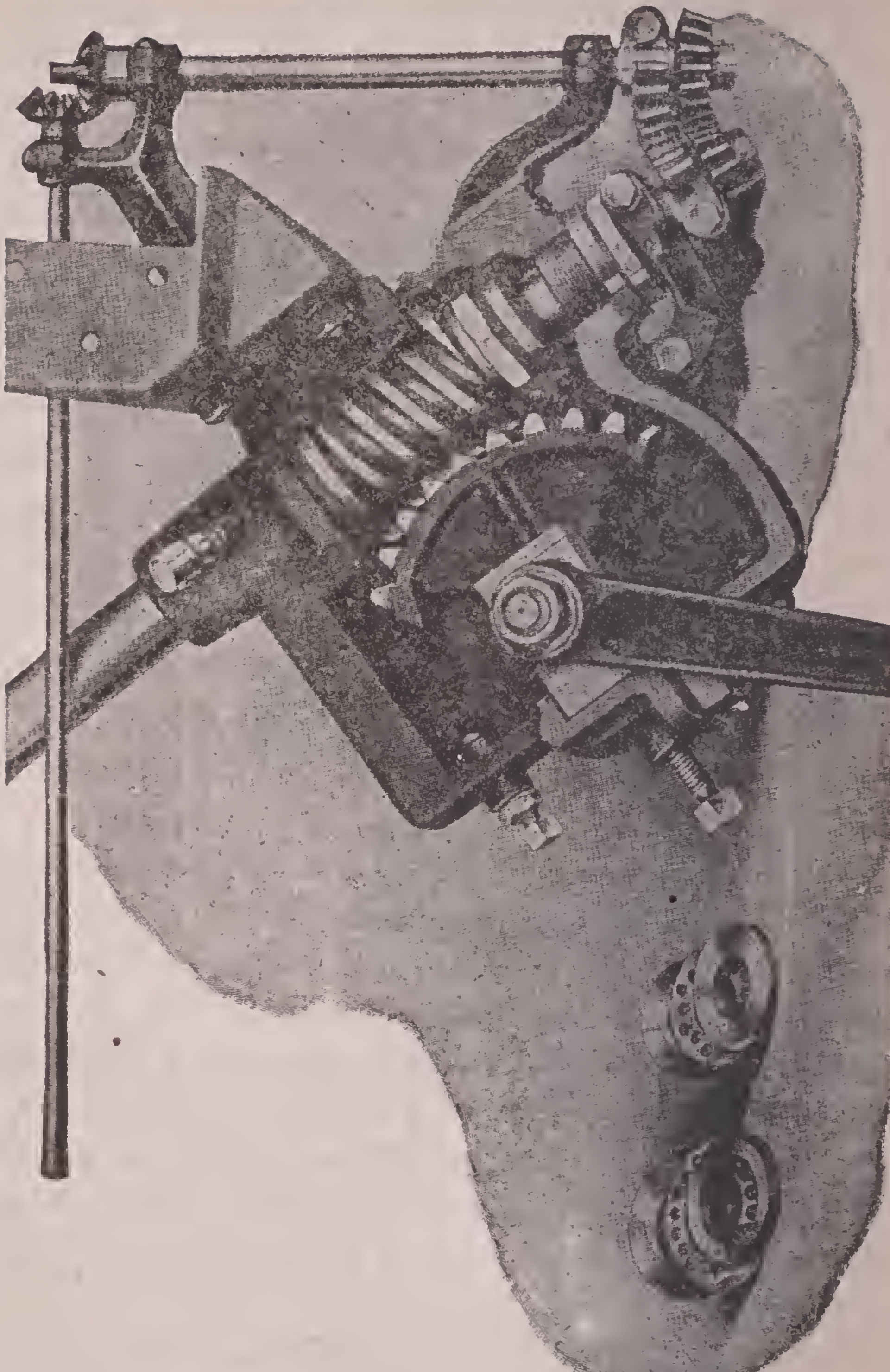


Fig. 316
Worm and Sector of Steering Mechanism

The gear should be taken down, given a thorough cleaning and examined for possible wear.

In case the steering action is stiff and the wheel turns hard, the ball joint may be out of adjustment due to wear; the steering link may be bent, or the cause may be insufficient lubrication. If there is any considerable amount of backlash, the cause may be looked for in the joints of the levers, in the swivel pin, or in loose bearings.

Strength of Metals. The strength of a metal is most often given in terms of the ultimate tensile strength. This is the load per square inch of

TABLE 13

TENSILE STRENGTH AND ELASTIC LIMIT OF METALS

Kind of Metal	Tensile Strength	Elastic Limit
Aluminum, cast	10,000- 16,000	4,000- 6,000
Brass, cast	12,000- 18,000	
" , rolled	30,000- 40,000	
" , wire............	60,000- 75,000	
Bronze, aluminum	80,000-100,000	50,000- 70,000
" , manganese.....	60,000- 80,000	25,000- 35,000
" , phosphor	35,000- 40,000	20,000- 22,000
Copper, cast...........	20,000- 35,000	10,000- 15,000
Iron, cast.............	14,000- 30,000	6,000- 20,000
" , malleable........	25,000- 45,000	10,000- 20,000
" , wrought.........	35,000- 50,000	20,000- 25,000
Lead	1,500- 2,500	
Steel, carbon, soft.....	50,000- 60,000	20,000- 30,000
" , carbon, .15-.30%..	60,000- 70,000	30,000- 40,000
" , " .30-.40%..	70,000- 90,000	35,000- 40,000
" , " , hard.....	90,000-110,000	35,000- 40,000
" , cast average.....	60,000- 80,000	30,000- 40,000
" , forgings.........	70,000- 90,000	35,000- 45,000
" , nickel...........	80,000-100,000	40,000- 75,000
" , vanadium........	60,000-230,000	40,000-150,000
Tin	3,000- 5,000	
Zinc	5,000- 6,000	

section at which the metal lengthens and does not come back to its original form. A measure of strength that is fully as valuable in pratical work is the elastic limit, this being the maximum load that the metal will carry, possibly with bending or slight elongation, but after which it will resume its original shape. Another quality of a material by which its strength is sometimes measured is the compressive strength in pounds per square inch of section, this being the load that the material will carry without permanent deformation, when this load acts in a direction which tends to crush the material being tested.

In Table 13 are given the tensile strengths

TABLE 14

SCREW THREAD STANDARDS

Thread Size	Threads per Inch U. S. S.	Threads per Inch S. A. E.	Tap Drill Size
1/4	20	28	7/32
5/16	18	24	17/64
3/8	16	24	21/64
7/16	14	20	3/8
1/2	13	20	7/16
9/16	12	18	1/2
5/8	11	18	9/16
11/16	..	16	39/64
3/4	10	16	43/64
7/8	9	14	25/32
1	8	14	29/32
1⅛	7	12	1 1/64
1¼	7	12	1 9/64
1⅜	6	12	1 17/64
1½	6	12	1 25/64

found under average conditions, also some of the elastic limits of the metals commonly used in automobile construction.

Threads, Screw. In Table 14 are given the number of threads per inch for the various diameters of screws in the United States Standard thread (Sellers) and also for the standard of the Society of Automotive Engineers (S. A. E.).

Tires, Care and Repair. Aside from gasoline the greatest expense in the upkeep of a motor car is the tires, and much of the present excessive tire wear may be reduced with reasonable precaution and care. There are ten common tire diseases, as follows: wheel out of alignment, under-inflation, use of anti-skid chains, skidding, running wheels in car tracks, neglect of casing repairs, tread cuts, running in ruts, stone bruises, use of inside protectors on new tires.

When a tire is on a wheel which is out of alignment the result is that the tire is scraped across the surface of the road and the resulting friction causes the tire tread to wear rapidly. The action of the tire on the road is crosswise at the same time that the tire revolves with the wheel. Thus the tire receives its usual wear plus the wear due to the scraping. The tread of a tire which has been run on a wheel out of alignment presents a rough appearance, that which would be given it were the tire held against an emery wheel for a while. Sometimes the fabric shows in places, and this is especially true of wheels which are wobbly. It is advisable to line up the wheels of a motor car about every three months, and if one is found which does not run true, the condition should be corrected immediately.

Perhaps as much harm is done by running a tire under-inflated as by anything else. Under-inflation, as the name implies, means that the tire is running with insufficient air pressure. Such a tire appears usually with a series of hilly blisters running around the tread. The blisters are caused by the separation of the fabric from the tread due to the excessive heat generated in an under-inflated tire. With insufficient air the flexing of the walls of the tire causes heat to be generated and this heat acts on the cement between the tread and fabric and in a short time the two separate, causing a blister to appear. Even in the summer a tire should not be run under-inflated. The common version is, that if the ordinary pressure is 80 pounds, a reduction of possibly ten pounds is made for summer weather. The belief is that the heat of the atmosphere will soon raise the temperature of the air in the tire and thus cause the pressure to increase to the proper point. This practice is not advisable, as there is undue wear on the tire while the pressure is being increased by the rise in temperature, and also because the pressure will drop as soon as the tire cools. The cure for under-inflation need hardly be stated. Keep the tires inflated to the pressure specified by the maker, which is usually 20 pounds per inch of cross-section. Thus, a 4-inch tire should carry 80 pounds pressure. It matters not if the pressure is a little more, but it does if the pressure is less than that for which the tire is designed. A tire guage, such as is sold for one dollar, should be one of the important instruments in the motorist's tool kit.

When anti-skid chains are applied to the tire too loosely or too tightly, the result sometimes is a cut tread. These chains should be placed on the tire so that they fit snugly and then no material tire wear will result.

Running a wheel in car tracks may soon cause the sides of the tire to become chafed, and in some instances the wear is so much that the tread loosens at the sides and begins flopping around. The same appearance may result if the car is driven very close to the curb and the side of the tire made to scrape the stone.

Little cuts in the casing often result in the casing being unfit for use in a short time. When a small cut appears and the tire is operated, dirt and water get underneath the tread. This dirt works its way around the tire under the tread with the result that the tire is soon loose. Water, as everyone knows, is detrimental to rubber, and more so to the fabric. Fabric begins to rot in the presence of water. The small cuts may be plugged with mastic.

Often a cut appears in the tread and an inspection finds that the fabric is injured also.

In such an instance the blowout patch is the first resort. The patch, if wrongly applied, sometimes becomes wedged in the fabric cut and in this way hastens a blowout. The best way to treat a tire with a reasonably large tread cut is to have the cut vulcanized immediately. In fact, even small cuts should be vulcanized at the first opportunity. The owner may say that the cost of having the tire vulcanized every time it is cut is expensive. It may seem expensive at first, but the saving in tire wear and repair later overbalances the comparatively small cost of vulcanization.

In the fall especially country roads present a mass of hardened ruts which play havoc with tires. These hard indentations house the tire for a while and then the driver will go over the rut. The driving in and out of these ruts creates a condition which puts a tire in the rut-worn class. The sides of the tread begin to show rapid wear and sometimes the wear is great enough to cause a weak spot in the tread, with the result that the tire blows out.

Stone bruises cause a great percentage of tire failure. When a tire runs over a stone, one as big a man's fist, there is a possibility of the fabric becoming broken. A broken fabric soon causes a blowout, so it remains for the driver to prevent as far possible running over such stones. Small stones sometimes present sharp edges which cut the tread and thus make an entrance for dirt and water. Stone bruises are hardly visible from the outside, as the condition is one of a fabric break, as mentioned above. The result of a stone bruise may be seen by examining the inside of the casing, which will show clearly that the fabric is injured.

Some makers state that the use of inside protectors on new tires is not advisable, as these appliances create an undue amount of heat in the tire and thus hasten wear. For old tires the inside protector is perhaps the best accessory marketed for lengthening tire life. Some owners have obtained as much mileage with old tires and inside protectors as they have from new tires operated without protectors.

Tire Vulcanizing. Absolute cleanliness is necessary in all vulcanizing work. No matter how good a vulcanizer you have or what kind of repair stock you use, the smallest amount of oil, grease or dirt will greatly impair the work. Therefore clean every repair thoroughly with a cloth or brush dipped in clean gasoline and roughen the point of repair with a rasp or coarse sandpaper while still wet.

Tires must be dry before beginning work on them, otherwise a porous patch will result. If you think, for any reason, that the canvas in the casing is even slightly damp, clamp the vulcanizer loosely over the tire for ten or fifteen minutes before applying the first coat of cement. Interpose a piece of waste or something of the sort between vulcanizer and tire to permit the escape of moisture.

It takes from fifteen to twenty minutes to vulcanize a layer of Para one-sixteenth of an inch thick if the thermometer is kept at 265 degrees, and five additional minutes for each additional sixteenth of an inch. Vulcanization will occur equally well at all temperatures between 250 degrees and 275 degrees. The lower temperatures require more, and the higher temperatures less time than stated above.

Inner tube punctures. Clean the tube thoroughly with gasoline and coarse sandpaper, for at least an inch all around the hole (be careful not to get gasoline inside the tube); then wipe with a cloth moistened with gasoline. When the gasoline has evaporated cement the edges of the hole and apply a thin layer of cement to the tube for three-quarters of an inch on each side of the hole. Let the cement dry until the gasoline has all evaporated and the cement is solid enough to resist the touch. "Tacky" is the usual word. Apply a second coat and let dry as before.

If a small hole, fill even with the surface of tube with layers of Para rubber cut the size of the hole, taking care that the Para sticks all around the edges. If a simple puncture, place a narrow strip of Para rubber over the end of a match and insert it into the hole. Cut off what protrudes outside the tube. Cut a patch of Para one-eighth larger than the hole or puncture and apply over same. Then cut another patch one-half inch larger than the hole and apply over the first. Cover and apply vulcanizer.

Repairs of this sort are to be vulcanized for fifteen or twenty minutes at 265 degrees.

Inner tube cuts and tears. Clean as directed both inside and outside of tube; coat edges of cut and inside and outside of tube with cement and let dry. The cement should extend three-fourths of an inch back from the cut.

Cut a strip of Para rubber as wide as tube is thick and stick on edge of cut; cut a strip one-half inch wide of Para rubber cured on one side, place it inside of tube under tear with cured side down, bring edges of tear together and stick them down to this strip. If you do not have any of the Para cured on one side regular Para may be used after cementing a piece of paper to inside of tube opposite the cut to prevent patch from sticking to opposite side.

Apply another strip of Para rubber one-half inch wide on the outside of the repair. Vulcanize for twenty-five minutes.

The first step in making a casing repair is, just as in the case of all tire work, to thoroughly clean the point of repair. Apply from one to three layers of cement, allowing each to dry. If the canvas is exposed, as in a scalp cut, put on enough cement to fill the pores of the canvas and leave a smooth surface when dry. Fill the hole not quite level with surface with Para rubber. The best results are obtained when casing repairs are slightly concave. If filled too full, the rubber will expand and flow over onto the unprepared surface in a thin film that will soon peel up and cause trouble. Moreover, a protruding patch will receive more than its share of hammering and will undoubtedly split open.

Tonneau. The name or term used in connection with the rear seats of a motor car. Literally the word means a round tank or water barrel.

Torsion Rod. When the manner in which the power is transmitted from the change-speed gear to the rear axle on the shaft-driven car is considered, it will be apparent that the turning of the shaft imposes a twisting strain on the whole rear end of the car, and that if it were not for the frame, and the weight of the car on the ground, there would be a tendency to revolve the rear of the chassis around the shaft, rather than to turn the wheels. But it would be bad practice to permit this strain to fall on the frame and hence the office of the torsion rod, which is designed to prevent its reaching that member. On cars that are not provided with independent torsion rods, it will be found that the housing of the propeller shaft has been made correspondingly stronger, and that its support has been designed to enable it to act in this double capacity. This represents a simplification of design that will be found on quite a number of cars, as it eliminates a part exposed to mud and dirt.

Traction of Driving Wheels. A horse which exerts a pull of about 375 pounds continuously for an hour and goes a distance of one mile in an hour is working at the rate of one horsepower. If for any reason the horse is unable to exert as much as 375 pounds pull when going at the rate of one mile per hour, he is thereby prevented from working at the rate of one horsepower.

The same rule applies to a motor car. When the road is not slippery there may occur a condition which does not appear with horse traction; that the tires fail to adhere to the ground owing to insufficient weight on the driving wheels. In such a case it is impossible for the motor-car to exert a push of 375 pounds without skidding the wheels, and thus it would be impossible for it to work at the rate of one horsepower. With underpowered motor-cars this difficulty does not occur, but to develop 10 horsepower at the rims of the driving wheels while covering the ground at the rate of one mile per hour, the car must exert a push on the road of 3,750 pounds. This is, on touring cars of ordinary weight, impossible, because the weight on the driving wheels is invariably less than 3,750 pounds, while the adhesion with the road is only a fraction of the weight on the rear wheels. As the speed rises, however, the push necessary for the development of 10 horsepower goes down until at 10 miles per hour a push of 375 pounds means 10 horsepower.

Thus a 40 horsepower car, if it could start work with the activity of forty horses, would, while it was moving at one mile per hour, exert no less a push than 40 x 375, which is equal to 15,700 pounds. This tremendous push is rendered impossible by the fact that the wheels of a car weighing 2,000 pounds only grip the ground enough to exert about 750 pounds push. Beyond this point they will skid.

This shows that a high-powered car, when the car is moving slowly, cannot develop its full power unless the road wheels are capable of adhering to the ground sufficiently to transmit this power. As a rule only about 0.6 of the weight of the car is on the driving wheels, and of that only 0.625 is available for the adhesion (owing to the coefficient of friction between rubber and road being 0.625). So a 10 horsepower car weighing 2,000 pounds cannot exert its full power when the car is starting, nor until it is traveling at 5 miles per hour.

It would be wrong to contend that on all cars having the weight distributed as at present, a 60 horsepower motor is useless, but it is needless to say that the output of such a motor is not availabe at starting or at any speed under 30 miles per hour, although the whole power is more needed then than at any other time. The remedy which suggests itself is by using all the adhesion of the car, that is, to drive with all four wheels.

Transmission. See *Change Speed.*

Trouble Location. See *Compression, Exhaust, Knocking, Pounding, Preignition, Repairs, Self Firing, etc.*

Unit of Heat. The heat unit or British thermal unit (B. T. U.) is the quantity of heat required to raise the temperature of one pound of water one degree, or from 39° to 40° F., and the amount of mechanical work required to produce a unit of heat is 778 foot pounds. Therefore the mechanical equivalent of heat is the energy required to raise 778 pounds one foot high, or 77.8 pounds 10 feet high, or 1 pound 778 feet high. Or again, suppose a one-pound weight falls through a space of 778 feet or a weight of 778 pounds falls one foot, enough mechanical energy would thus be developed to raise a pound of water one degree in temperature, provided all the energy so developed could be utilized in churning or stirring the water.

Vacuum Fuel Feed. See *Fuel Feed, Vacuum.*

Valves. There are two valves, one inlet and one exhaust, for each cylinder of a four cycle internal combustion engine. Some engines of recent design provide four valves in each cylinder, two of each kind. Four types of valves are in use; the poppett, the sleeve, the rotary and the disc.

Typical designs of poppett valve installations are shown in Figures 317 and 318. Both valves shown are of the mechanically operated type, the only method of operation at present in use. Such valves are opened by means of cams mounted on the cam shaft of the engine and are closed by the force of coiled springs placed around the lower part of the valve stem and attached to the end of the stem.

There are three locations for the valves with reference to the combustion space of the engine cylinder, all methods being in more or less common use. The most popular location is in placing both inlet and exhaust valves in a single pocket at one side of the combustion space, such a design going by the name of an "L" head engine. In other cases the exhaust valve is in a pocket at one side with the inlet in a similar pocket on the other side, this engine being called a "T" head. Overhead valve engines are made with both valves opening into the top of the combustion space and operated by some form of rocker arm mechanism actuated from the cam shaft through vertical push rods. Overhead valve engines may also be made with the cam shaft carried above the cylinders.

Pocketed valves can be exposed and removed

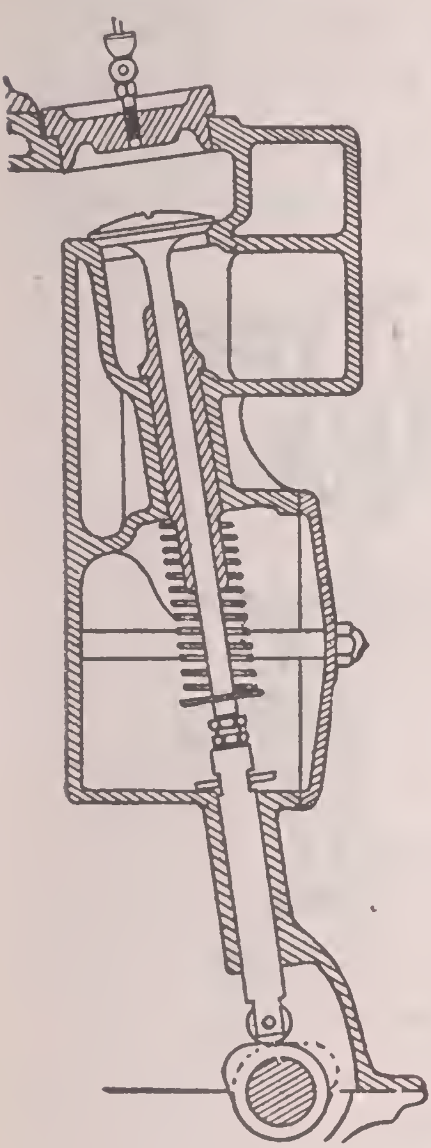


Fig. 317
Inclined Poppett Valve

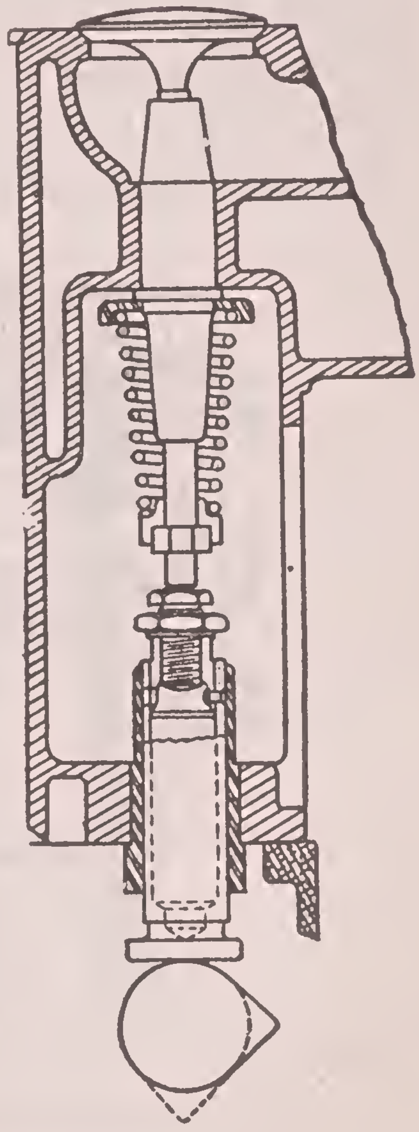


Fig. 318
Intake Valve, Poppett Type

through screw caps placed above the head of each valve and in the top of the pocket. Overhead valves are carried in cages which form the valve seat, the cage then being fastened into the head of the cylinder.

SLEEVE VALVES. During the last few years there has been placed on the market a type of engine that does not have poppett valves, but which has a type of valve known as a "Sleeve Valve." See *Engine, Sliding Sleeve Type.*

Sleeve valves are made by placing two sliding

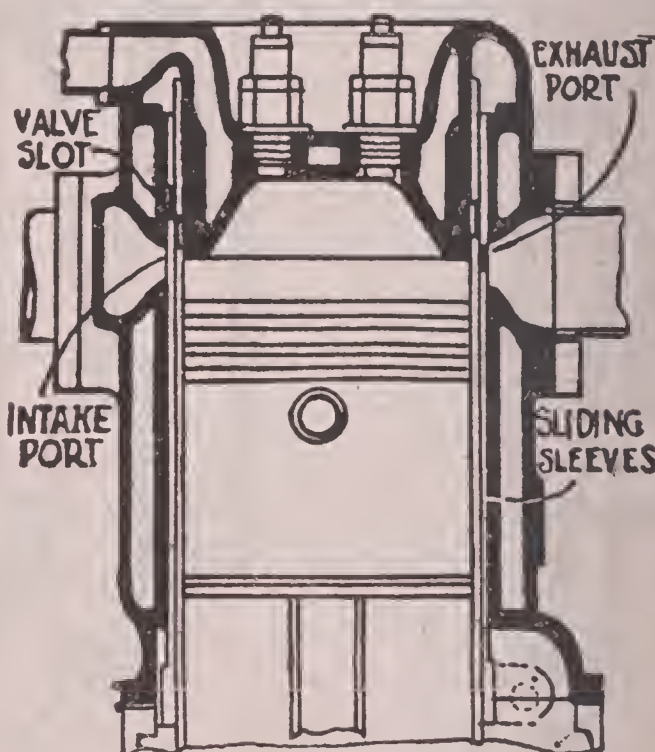


Fig. 319
Sliding Sleeve Valves

sleeves between the piston and the cylinder walls, Fig. 319. These sleeves are shaped like a section of tubing and are about an eighth of an inch thick. There are holes or slots cut through the sleeves near the top, that is, in the part of the sleeve nearest the cylinder head.

The holes, or "ports" as they are called, are placed so that when the sleeves are placed in a certain position the holes are opposite each other. When they are opposite each other they will let the mixture through into the cylinder or let the burned gas out into the exhaust pipe, depending on which thing it is necessary to do.

The lower ends of the sleeves connect with small connecting rods which are worked up and down by eccentrics on the shaft that takes the place of the cam shaft. These small connecting rods move the two sleeves up and down so that when the piston is ready to start down on the inlet stroke two of the openings come opposite each other, one opening in each sleeve. These two openings are brought opposite the opening that goes to the carburetor at the same time they are opposite each other so that the fresh mixture can be drawn into the cylinder.

After the piston passes bottom center the sleeves are moved so that the openings are not opposite each other or the opening to the carburetor and the fresh gas is shut off.

When the piston is most of the way down on the power stroke two ports on the other side of the sleeves, one opening in each sleeve, are brought opposite each other, and at the same time opposite a hole that opens into the exhaust pipe so that the burned gas can get out of the cylinder. After the piston finishes the down stroke, goes up on the exhaust stroke, and is just past top center, the two openings are moved so that they close the hole into the exhaust pipe and then the inlet openings come opposite each other again.

These sleeves are adjusted to open and close at just the right time by adjusting the length of the small connecting rods.

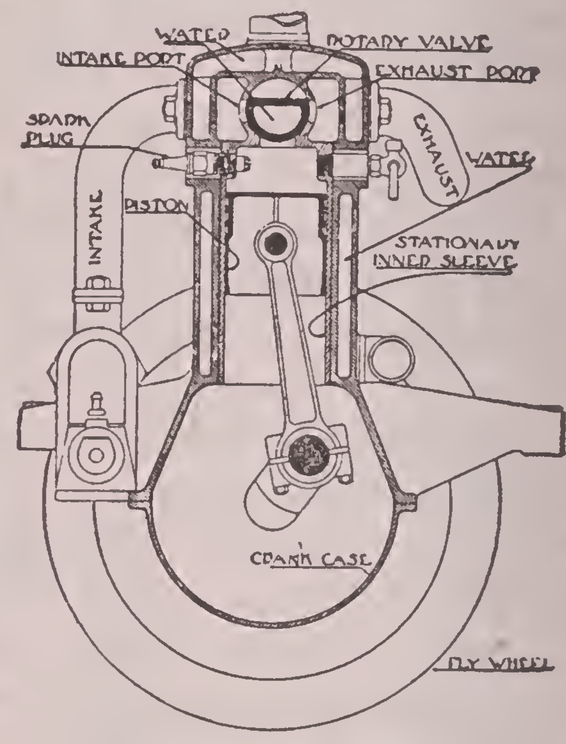


Fig. 320
Engine Having Single Rotary Valve

The opening and closing of the ports should come simultaneously with the opening and closing of the inlet and exhaust valves in a poppett valve engine.

Rotary Valves. Other engines are made without either poppet or sleeve valves but with a type of valve called a "Rotary Valve."

Rotary valves, Figs. 320 and 321, are made by having a long round shaft run along the side of the cylinders near the cylinder heads. Holes are bored through this shaft so that the holes come opposite openings into the cylinder or combustion space and at the same time open

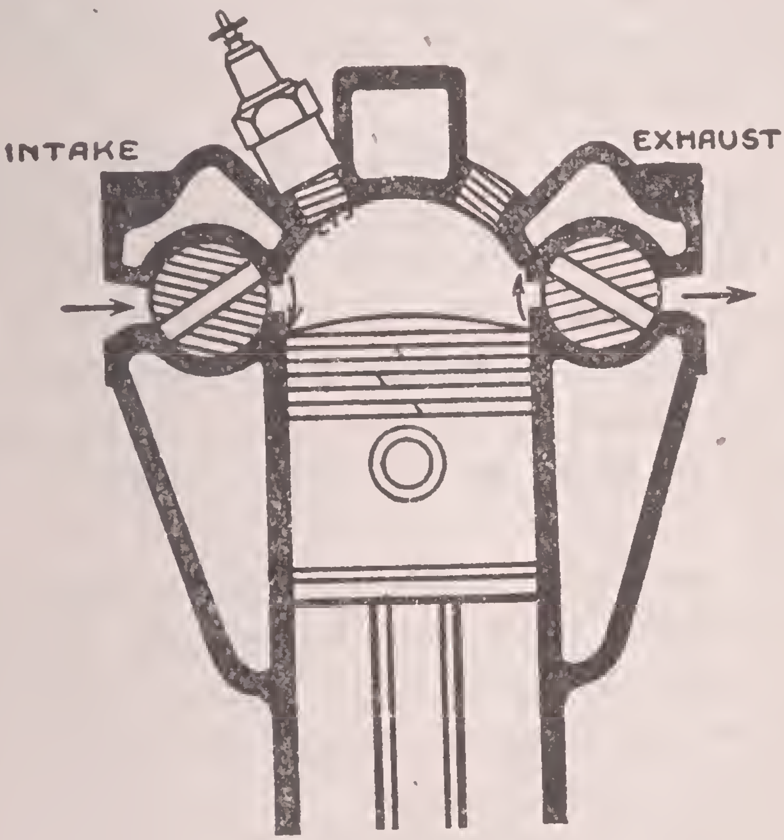


Fig. 321
Engine With Separate Rotary Valves

into the pipe leading to the carburetor or to the exhaust pipe, according to the position the piston is in and the stroke it is making.

This long shaft or valve is set in a position to open the inlet holes at the same time as the inlet valves should open in a poppet valve motor, to close the inlet holes at the time the inlet valves should close, and to open and close the exhaust holes at the same time as the exhaust valves should open and close in a poppett valve engine.

The rotary valve is driven from the crank shaft by gears or chains so that it turns half as fast as the crank shaft, just the same as the cam shaft would turn.

DISC VALVES. There are still other engines made with a type of valve known as a "Rotary Disc Valve." These valves are in the shape of a piece of round iron as large around as the top of the piston and about a quarter inch thick. They are placed on the top of the cylinder and fastened to gears so that they rotate or turn around.

Holes are cut through the disc so that they come opposite holes cut through the cylinder head. Some of these holes connect with the pipe that goes to the carburetor and others connect with the exhaust pipe.

The discs are made to turn so that the inlet holes and exhaust holes are opened and closed at the same times as the inlet and exhaust valves are opened and closed on a poppett valve motor.

All of the matter pertaining to valves on the following pages refers to the poppett type and covers the subjects of timing, clearance, grinding, etc. Subjects related to that of valves are treated under the head of *Engine*.

Valve Clearance. A large number of motors, especially old ones, are unnecessarily noisy because of superfluous clearance between the valve lifters and the valves, and a great part of the noise may be eliminated simply by the expenditure of a little time and care in reducing this clearance to the minimum. Every valve cam, no matter what its shape otherwise may be, is tangential at the first and last portions of the valve's movement. The sooner the valve takes hold of the cam on the lift, and the later it lets go on the descent, the slower will be the

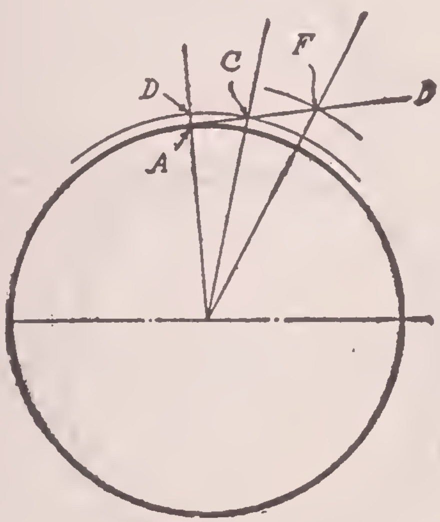


Fig. 322

movement of the valve at these instants, and the less will be the shock both of the lifter on striking the valve stem, and of the valve head on meeting its seat. Fig. 322 shows this clearly. The tangent line A B starts at A, and during the arc D C the rise of the cam amounts only to a minute distance A D.

The objection to an excessive clearance is not simply the vertical hammering, but the sidewise pressure imposed on the valve-lifters by the cams, particularly at the instant of opening the exhaust-valves. If it were possible to operate the valves with no clearance whatever, and if there were no lost motion, and if the whole mechanism were ideally rigid, the line of pressure of the cam at the instant could be said to

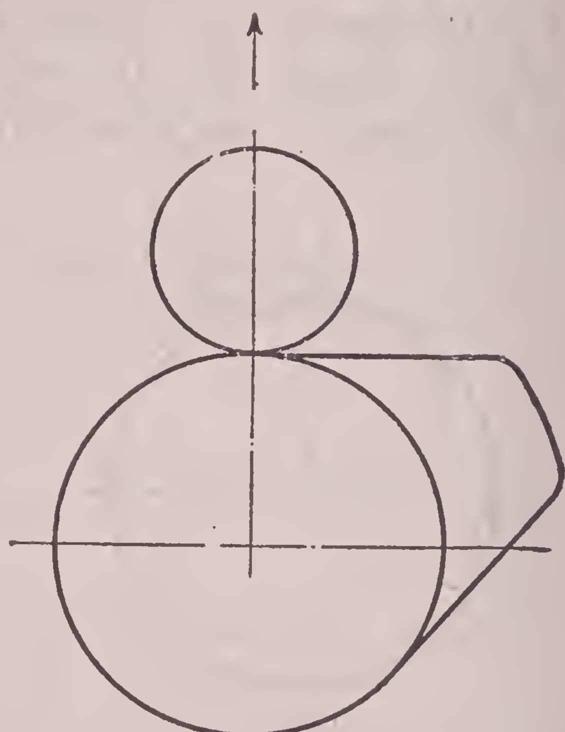


Fig. 323

be vertical, and there would be no side thrust till the valve was off its seat and the pressure of the gases on the valve was partly equalized. As the matter actually stands, however, there is a side thrust which is considerably increased by unnecessary clearance, as comparison of Figs. 323 and 324 clearly shows. In Fig. 323 there is no clearance, and the tangent to the line of contact is horizontal. In Fig. 324 there is a clearance, AB. The thrust acts at right angles to the tangent along the line C D, and if C E represents by its length the force required to overcome the pressure on the valve and the force of the spring, there is a horizontal thrust equal to D E. It goes without saying

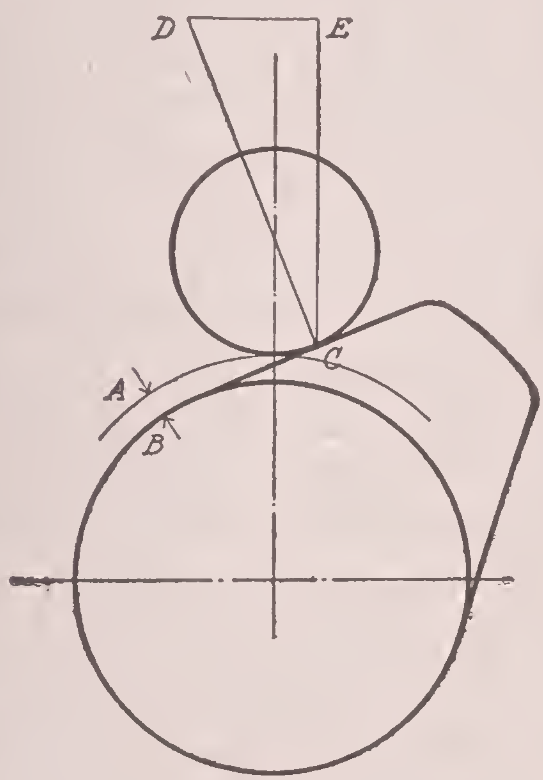


Fig. 324

that valve-lifters thus adjusted will wear loose in the guides faster than they should. As the gas pressure on the valve head may amount to 30 or 40 pounds per square inch the instant before the valve is open, there is an evident tendency to wear a hollow in the cam at the precise point where it starts the exhaust valve from its seat. Evidently, moreover, the smaller the clearance, the greater will be the leverage of the cam, and the smaller will be its wearing tendency.

The precise amount of minimum clearance is hard to state arbitrarily. The thickness of a business card or about 10-1,000th of an inch is ample allowance for the expansion of valve stems for the average length.

Valves—Lead of. The higher the speed of the motor the greater the necessity for giving both the exhaust, and the inlet valves what has come to be known as a "lead," in that they open before the completion of the particular part of the cycle that they are intended to perform. It must be borne in mind that time is required to set a thing in motion and to stop it, regardless of its form or weight, and this is true of a gas, which has inertia the same as other substances. Further, an appreciable period, though very short indeed, is required for the creation of the vacuum in the cylinder. The gas does not rush into the combustion chamber the moment the inlet valve opens; the piston must have traveled downward a bit before this takes place and the column of gas then rushing in attains an increasing velocity as the piston approaches the lower center.

Valve Timing. Before proceeding with the operation of valve timing, the proper clearance between the ends of the valve stems and the operating mechanism driven from the cam shaft should be secured.

The time or point during the engine cycle and during the revolution of the flywheel at which the valves open and close is specified in degrees of the circle measured on the rim of the flywheel. One complete circle, or the entire distance around the rim of the wheel, equals 360 degrees. Therefore, one stroke of the piston, being one-half of a full revolution of the flywheel, equals 180 degrees. The inlet valve will open during the first half revolution of the flywheel, or during the first 180 degrees on the rim of the wheel. During the next half revolution, the compression stroke, neither of the valves are open, and likewise, on the third, power stroke, both valves are closed. During the fourth half revolution, the exhaust stroke, the exhaust valve is open. Because of the fact that the valves open and close somewhere near either the top or bottom of the several strokes, their opening and closing positions are specified in the number of degrees before or after the top center, this being the point at which the piston is at the exact top of its stroke, or else the time is specified as before or after bottom center, this being the point at which the piston is at the exact bottom of its stroke.

The valve action for any one cylinder of a four cycle engine is shown in Figures 325 to 328. In Figure 325 is shown the beginning of the inlet stroke with the piston at top center and with the inlet valve about to open. The opening of the inlet valve is generally made to occur from 2 to 10 degrees after top center.

In Figure 326 is shown the position of the valves and cams at the beginning of the com-

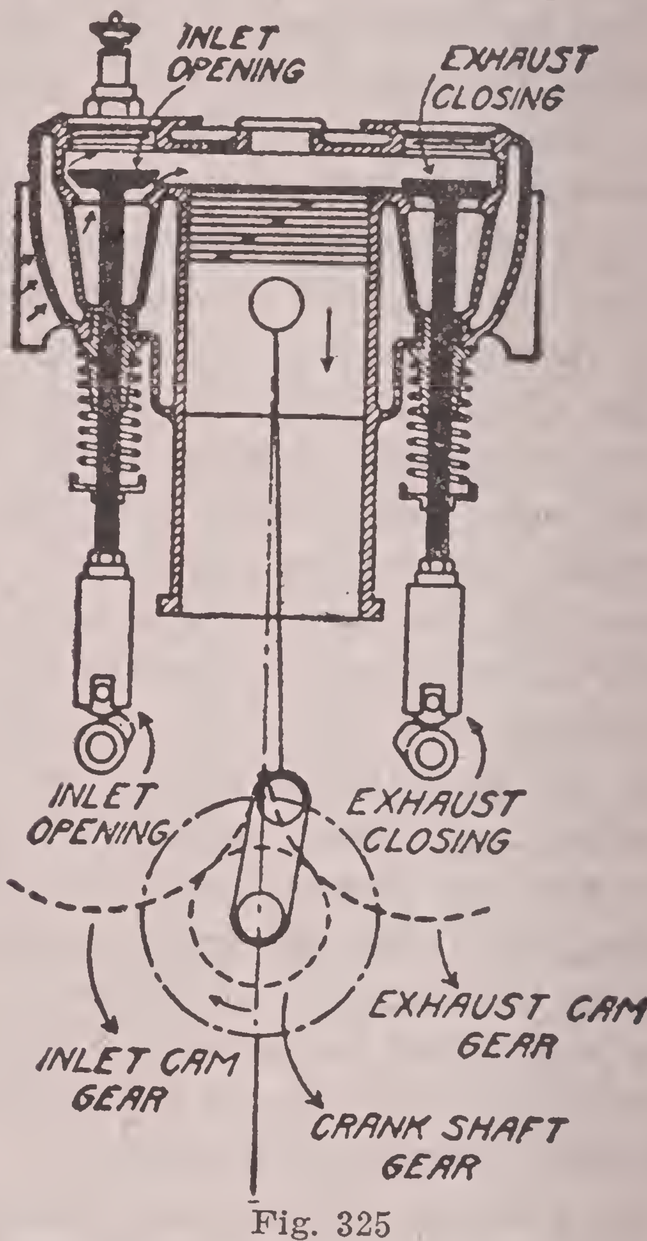


Fig. 325

pression stroke with the inlet just closing. This closing point is usually from 20 to 40 degrees after bottom center, allowing the inrushing gas plenty of time to fill the cylinder.

In Figure 327 is shown the end of the power stroke with the exhaust valve starting to open This opening should occur from 40 to 75 degrees before bottom center so that the burnt gas will have an opportunity to start passing out in

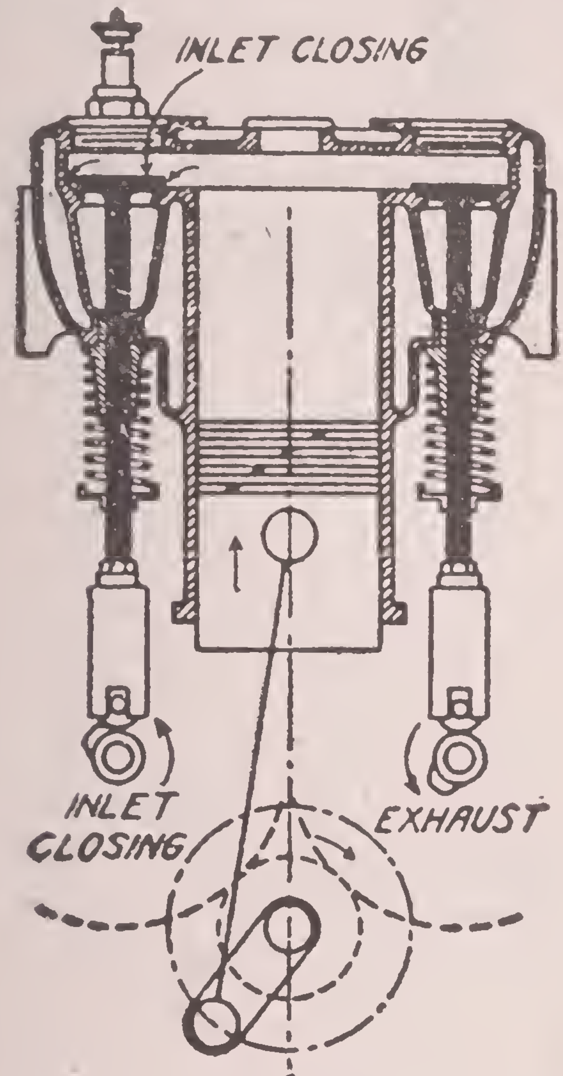


Fig. 326

time to make a fairly complete exhaustion and avoid back pressure during the following upward stroke of the piston.

In Figure 328 is shown the end of the exhaust stroke with the exhaust valve closed, this closing taking place just before the opening of the inlet valve for the ensuing intake stroke, or, in some high speed engines, the exhaust valve may remain open for two or three degrees after the inlet starts to open.

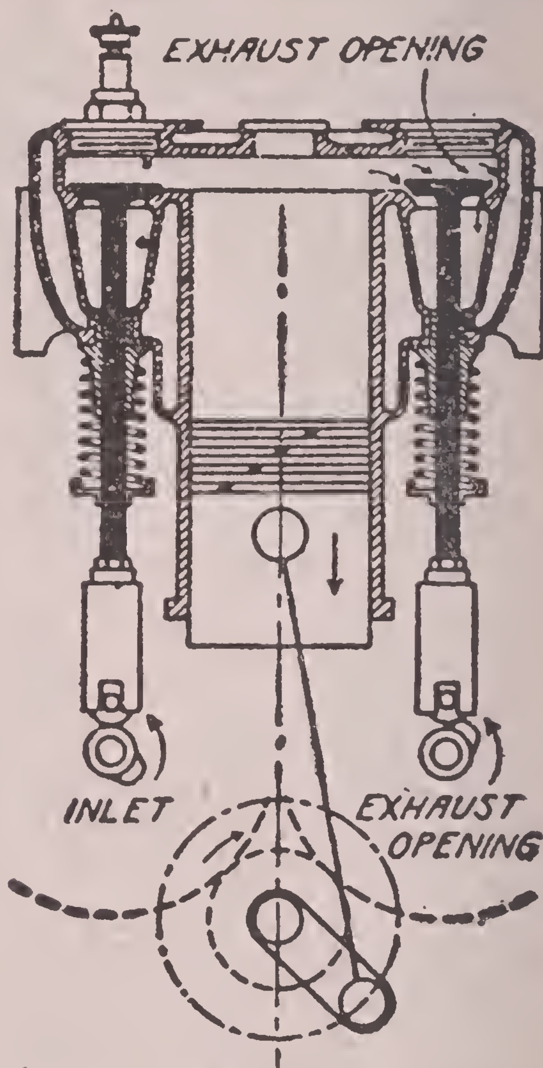


Fig. 327

The time during which the valves are open and closed during the four strokes is shown in Figure 329. From this drawing it will be evident that the inlet stroke, measured by the valve opening time, lasts from 6 degrees after top center to 30 degrees after bottom center, or a total of 204 degrees. The compression stroke lasts from 30 degrees after bottom center to top center, at which time the piston starts down again, making a total of 150 degrees. The

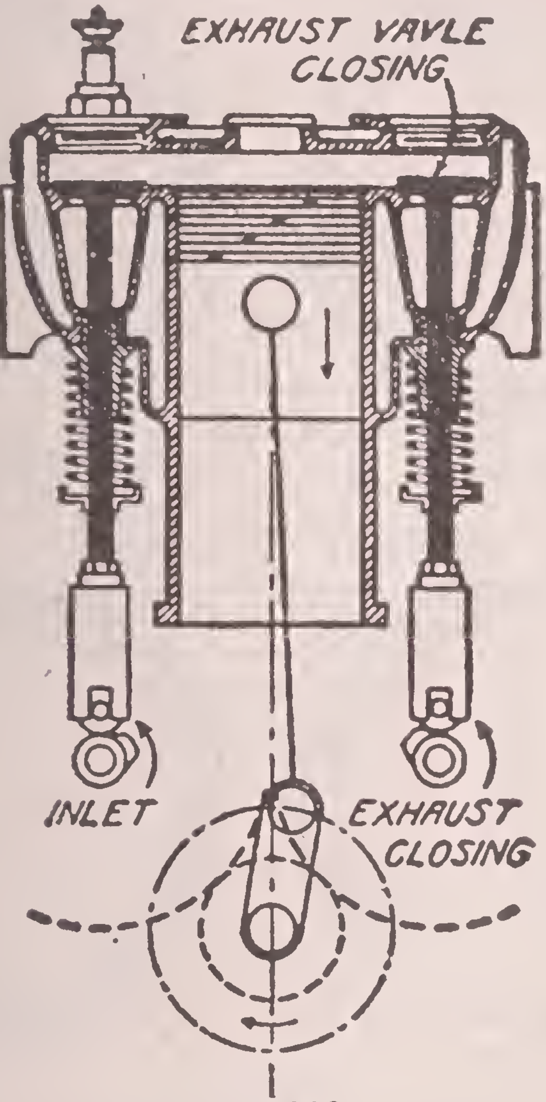


Fig. 328

power stroke, presuming complete ignition to take place at top center, lasts from this point to 50 degrees before bottom center, or a total of 130 degrees. The exhaust stroke, longest of all, lasts from 50 degrees before bottom center, all through the up stroke, and until 5 degrees after top center, making a total valve opening time of 235 degrees.

The examples given represent only average

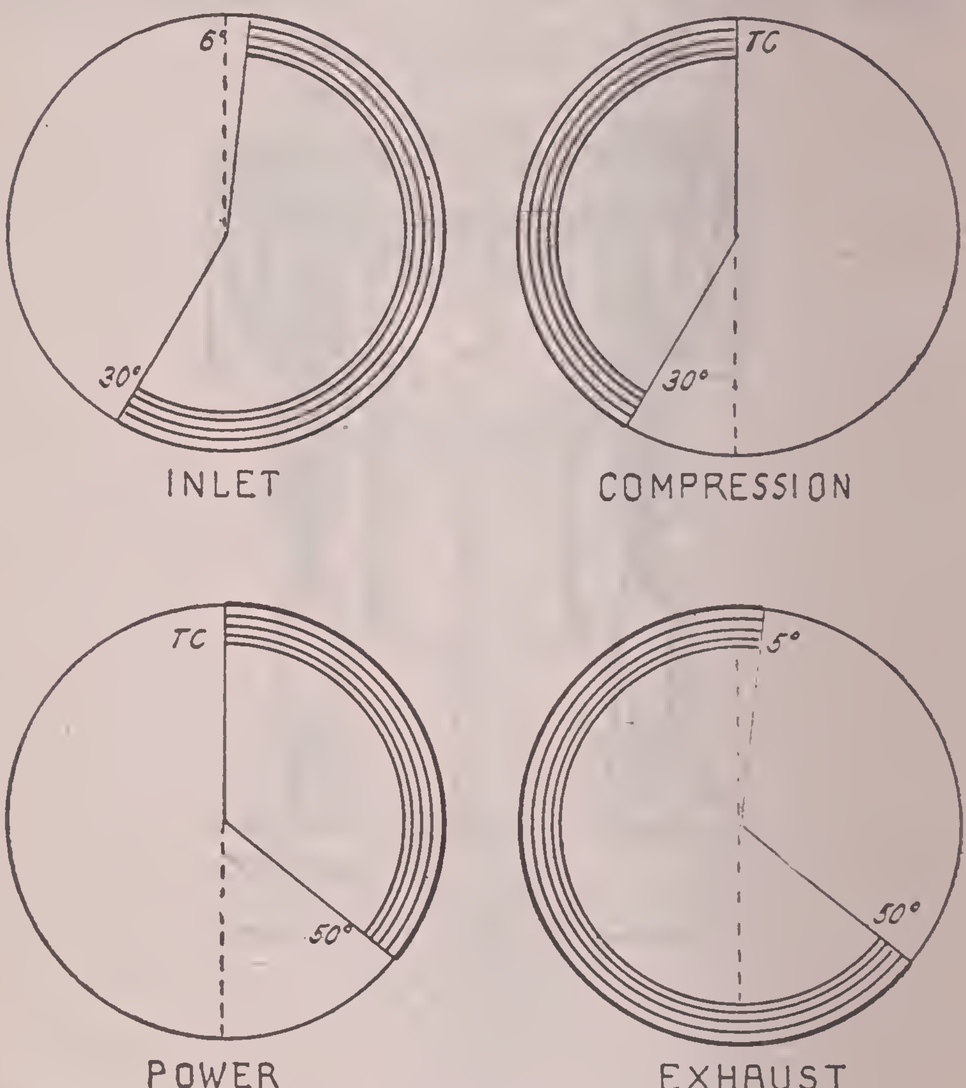


Fig. 329
Time of Valve Opening

practice and it should be understood that the best valve setting for any one engine may be found by inquiry from the makers of the car or engine, or from a study of their instructions.

In many cases the points of opening and closing will be found marked on the rim of the flywheel.

Valve Grinding. To grind a valve proceed as follows: First loosen the lower end of the valve spring from the lower end of the valve. This may be held by a number of different devices such as washers with pins under them, or grooves cut in the valve steam into which a washer slips. To loosen the spring it must first be pried up from the bottom, that is, so the end of the spring is held away from the end of the stem. This may be done by a special valve spring lifter or the repairman can make a forked lever so that the prongs fit on each side of the stem and lift the spring by resting the lever on some solid piece. Sometimes the spring can be lifted by taking a common screwdriver and using it to pry with. Before the spring can be raised, however, the cap that covers the head of the valve must be removed or at any rate the head must be reached. Now take a screwdriver or hammer handle or a piece of wood and wedge it into the valve pocket so that the head of the valve cannot lift. If this was not done the whole valve would lift when you pried up on the spring.

After the spring is pried up out of the way remove whatever locking device was holding it and then the valve may be taken out of the hole above the valve head by letting the stem slip through the spring and locking parts. You can now examine the face and seat and you will probably find them pitted. Also examine the stem, and if it is dirty or covered with soot (called carbon in the automobile business), it should be scraped clean with a knife blade or some sharp instrument. There must be no ridges on the valve stem that might keep it from seating the valve properly.

A valve stem must never be oiled or greased under any conditions. They are designed to work dry.

The valve is ground by placing some cutting material between the seat and face and rubbing them together. Valve grinding material may be made by taking emery powder of a fine grade and mixing it with enough engine lubricating oil to make a rather thin paste, or it may be made by mixing the emery with lubricating oil and kerosene. It may also be made by mixing powdered glass with a thin oil into a paste, this being used mostly for finishing the operation. If a very fine fit is desired a paste can be made with crocus powder and oil. A rather coarse paste is used at first if the surfaces are badly pitted and the finer, smoother pastes are used for finishing.

After making the paste take a cloth (not a piece of waste), tie a string to it and stuff the cloth into the opening from the valve pocket to the combustion space. This is to keep the grinding material out of the cylinder, where it would do great harm.

On the top of the valve head you will find a slot for a screwdriver or else some holes that take the end of a special fork-shaped tool. These let you turn the valve face on the seat, and you will need a tool that fits the particular valve head you wish to work with. You will also need a small can of gasoline or kerosene handy so that the grinding compound may be washed from the valve and seat.

The operation of valve grinding consists of placing a small amount of the grinding compound evenly on the face but not very thick. What you can easily pick up on the tip of a pocket knife blade is plenty at one time. The valve is now placed in the cylinder or part that it came out of so that the face rests on the seat. Now take the tool that turns the valve and turn the valve about half way around and then back again. Do this several times. Do not use much pressure as the pressure forces the grinding compound from between the face and seat and makes the work slower.

After making several half turns the valve head must be raised and turned to a new position while it is not touching the seat, and then the operation is repeated. If you do not raise the valve from the seat every few half turns you will make ridges on the face and spoil the job. Also, if you turn the valve round and round without reversing the motion and raising it you will spoil the work. In order to raise the valve from the seat every once in a while you can take a light spring that fits around the stem and place it on the valve stem just under the head. This spring should rest on the metal of the cylinder at its lower end and hold the valve about a half inch off the seat. When you press on the valve grinding tool the valve will be pressed down onto the seat, but when you release the pressure it will raise again and you can turn to a new position without pushing up on the stem from below.

The valve must be ground for a few minutes and then washed off and carefully examined. When the face and seat are a clean even light gray all around and have no marks or pits or rings at any point the job is finished.

The next thing to do is to test the valve for tightness. This can be done by placing pencil marks at short distances all around the face and then pressing the valve down and turning it once around. If the marks are all off the face it will be tight. You can also pour gasoline or kerosene on top of the valve and watch for it to run down the stem. If it does not leak through it is tight.

Now wash every trace of grinding material from the valve and the seat and valve pocket and replace the valve with the spring and the valve cap.

Pitted Valves. A valve in a pitted condition causes bad compression, and the exhaust-valve should be ground occasionally. After grinding the exhaust-valve be sure that there is ample clearance between the valve and the lifter. It should have not less than one hundredth of an inch, otherwise when the valve becomes hot it will not seat properly, poor compression being the result. In grinding a valve there is no occasion to use force, and the grinding should be done lightly, the valve being lifted from time to time so that any foreign substance in the emery will not cut a ridge in the seat, or the valve itself. After grinding the valve always wash out the valve seat with a little kerosene, and be careful that none of the emery is allowed to get into the motor cylinder.

A good mixture for grinding valves may be made by using fine emery and cylinder oil mixed in the form of a paste convenient to work with.

EXHAUST-VALVE STICKING. Sometimes a motor may suddenly stop from the failure of the exhaust-valve to seat properly. This may be due to the warping of the valve, through the motor having run dry and become hot, or it may be from the failure of the valve spring, or the sticking of the valve-stem in its guides. The valve should be removed, and the stem cleaned and scraped, or straightened if it requires it, until it moves freely in the guide, and the spring is given its full tension. If the valve still leaks so that the motor will not start or develop sufficient power, the valve will have to be ground into its seat.

Vulcanizing. See *Tire Vulcanizing.*

Watt-Hour—Definition of. A current of one ampere flowing in an electric circuit, with an electro-motive force of one volt, is equal to one volt-ampere or one watt. The voltage of a circuit, multiplied by the rate of the current flowing in amperes, gives the rate of work, or energy expended in watt-hours.

It is oftentimes found that electric lamps for automobile lighting are rated according to their consumption in watts rather than directly in amperes. The number of candlepower secured from each watt consumed will vary according to the size of the lamp in candlepower, the material of which the filament is made and the type of bulb, whether vacuum or nitrogen. A small bulb with tungsten filament will use from 1.10 to 1.25 watts per candlepower, and this is reduced until in the largest candlepower the rate is about 0.95 watts. The consumption with carbon filaments is about two and one-half times that with tungsten. Nitrogen bulbs use less current than the vacuum type.

Welding—Autogenous. This process consists of welding, or, more correctly speaking, melting together metals by means of the oxyacetylene flame, the temperature of which almost rivals that of the electric arc, being 6,300 degrees Fahrenheit. The facility with which it can be handled as compared with most other methods makes its commercial application comparatively simple. The possibilities attendant upon the use of a flame of such high temperature can be realized when it is remembered that the melting point of steel is about 2,570 degrees and that of platinum, one of the most refractory metals, is only 3,227 degrees Fahrenheit. Its chief field of usefulness is in combining such metal parts as would ordinarily be riveted, in welding small parts together, in repairing broken or defective castings and for cutting metals of any nature or size that occasions demand.

As it is possible to unite many dissimilar metals, and with a heat so localized that neighboring parts are not affected, autogenous welding has already found an extensive application in motor car repair work. Broken crankcases or other parts can be united and made practically as strong as new. The method of holding the pieces of a broken aluminum case, for example, is to clamp them into position temporarily while clay is packed around the parts and heated sufficiently to drive out the moisture, thus forming a solid support for the parts as well as a kind of mould. A series of holes are usually drilled at the crack, or the edges of the pieces are roughly beveled so, as previously explained, the metal can be built up from the bottom. In some instances lugs or peculiar shaped projections may have been completely worn off or destroyed, when it becomes necessary to build up new ones with additional metal. In repairing a cracked waterjacket, after the edges of the crack have been prepared, it is customary to use copper instead of iron wire for the filling metal as it flows at a lower temperature and adheres very positively. In case there is danger of warping, due to local expansion, the entire cylinder is heated before operating upon it.

Wheels. The wood work of all wheels should be of selected grades of second growth hickory, or equally good growths of other hard woods. In the driving wheels the twisting moment of the motor is transmitted to the spokes of the wheels, and this torsion must be resisted by the wood at the miter, therefore, if the hub flanging is not clamped tight there is danger of the joints "working," which will soon lead to something worse. When the hub clamping bolts are tightened up they should be so pinned that they will not turn with the nuts because if the bolts do turn it will be impossible to apply sufficient pressure, and the clamping effort will be insufficient. Fig. 332 shows a hub in which the clamping bolts are prevented from turning by means of a triangular shaped extension just under the bolt heads, which engages a slot in the flange. In this hub the flange is made integral with the brake drum, which also serves for the sprocket wheel, and the torsional effort is taken by integral metal at all points, thus relieving the wood work from shock. The nuts used on the clamp bolts shown in Fig. 332 are castellated, although it is not necessary to use castellated nuts unless the flanges have to be removed, which in modern construction is

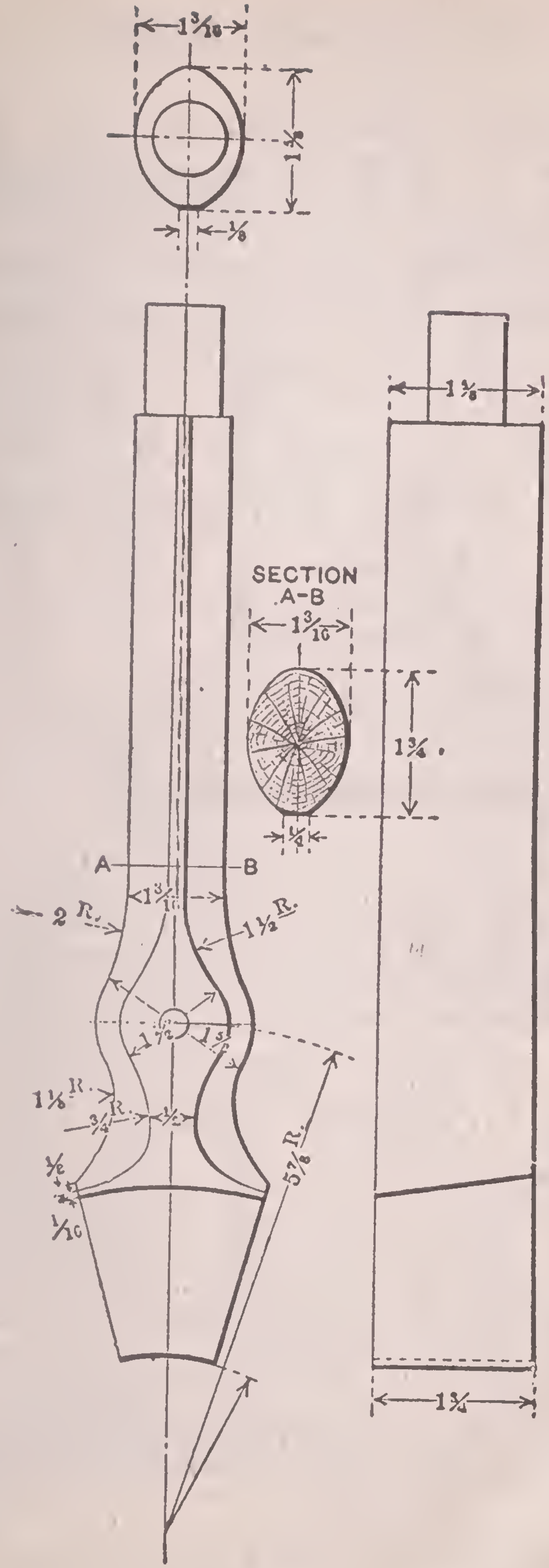


Fig. 330
Rear Wheel Spoke, Showing Proportions

the exception, rather than the rule. In ordinary practice if the wood is thoroughly seasoned, plain nuts, if screwed up tight will hold without resorting to the method so common in shop practice of riveting the ends of the bolts over the nuts. The elastic nature of the wood will serve to hold the nuts in place. Regarding spokes, a certain symmetry of contour is necessary if they are to be machine made. Fig.

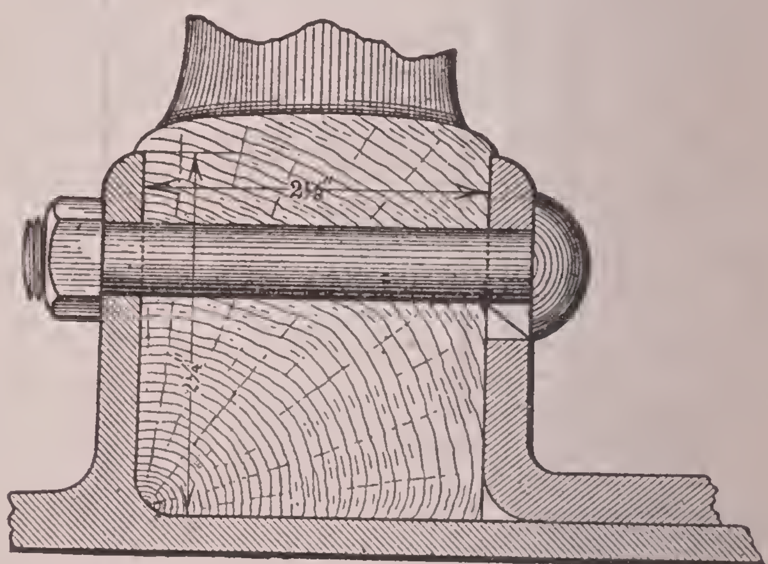


Fig. 331
Section of a Hub at the Miter Showing Depth of Flange and Method of Clamping

330 shows a spoke in which all the advantages known to wheel making are embodied, and the depth of flanging is that which experience dictates as adequate. The dimensions of the spoke are shown in detail in the cut. The brake drum is bolted to the spokes at a considerable radius, thus eliminating excess strain on the wood work.

The strength of the spoke depends in a large

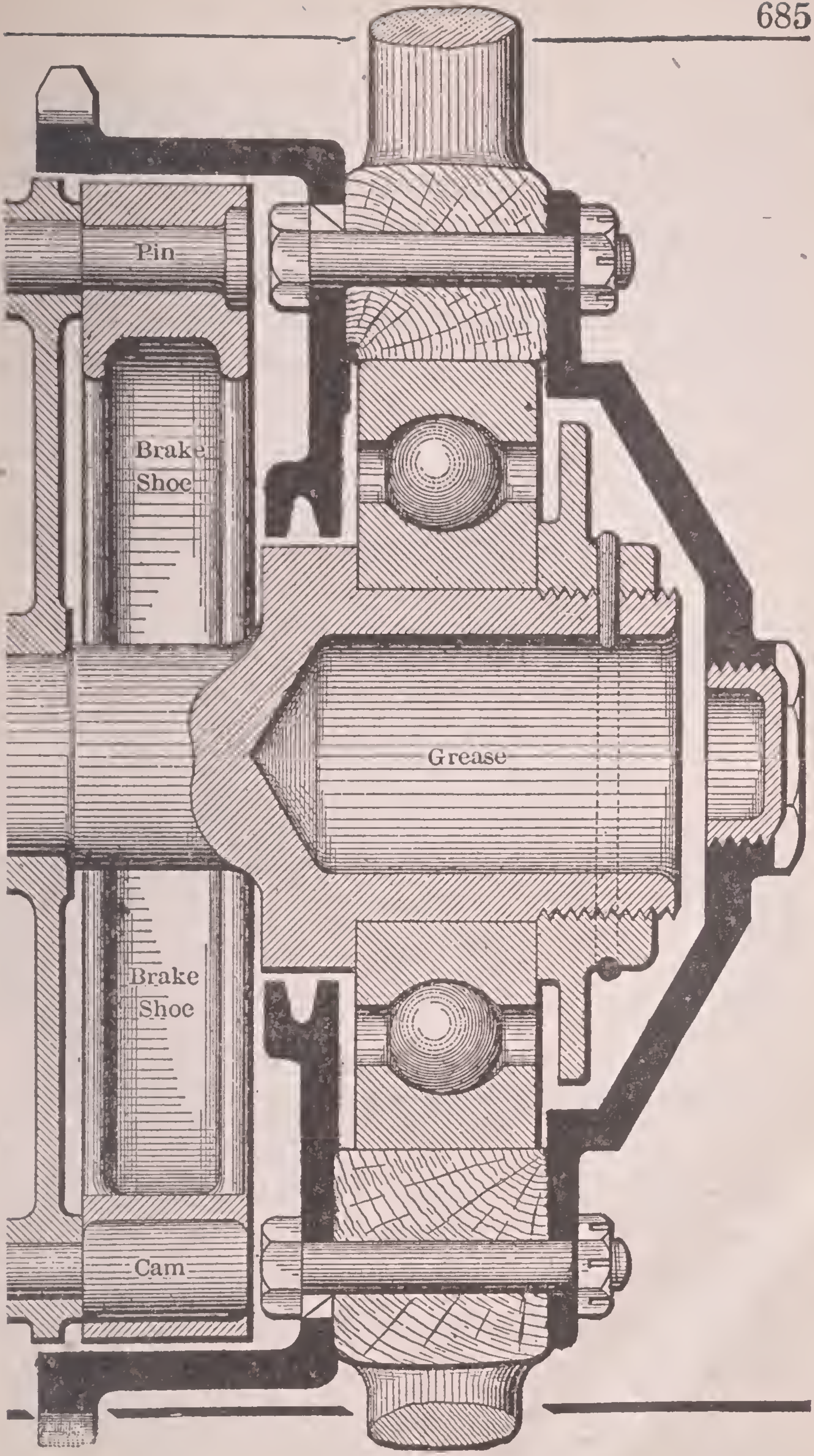


Fig. 332
Section Through Rear Wheel with Combination Brake Drum and Inner Flange

measure upon its thickness in the axle plane at the hub flange, which in Fig. 330 is 1¾ in. The second point of importance is at A, B, where the largest diameter is also 1¾ in., but in the plane of the wheel instead of the axle. At the tenon engaging the felloe, this spoke is 1⅝ in., in its major diameter, which is the plane of the

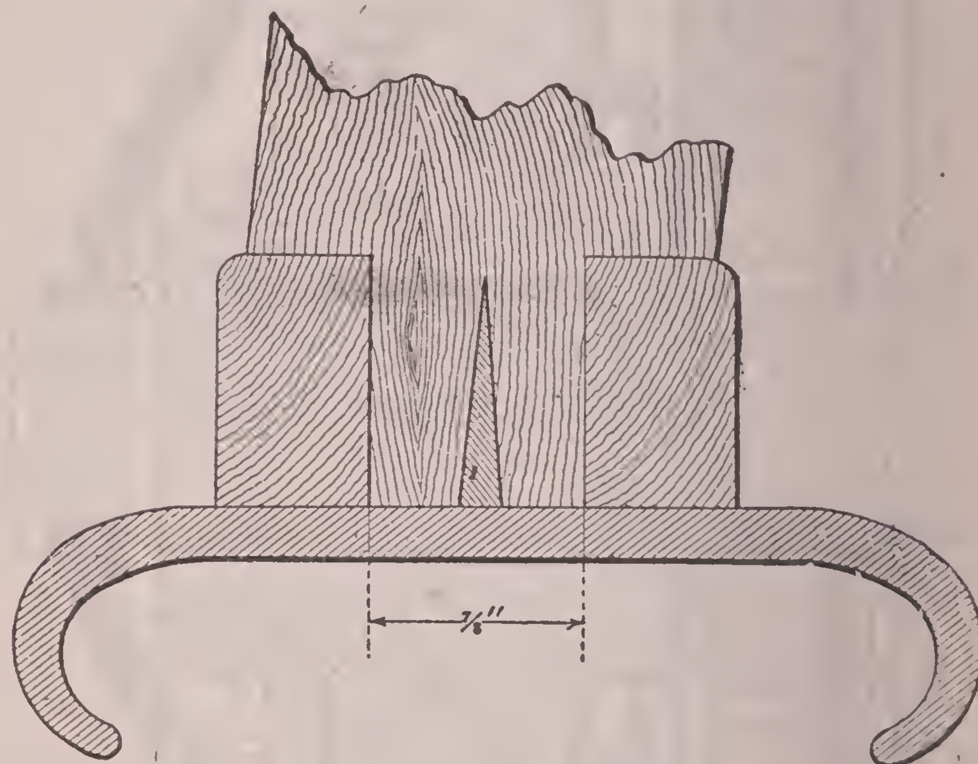


Fig. 333
Section of Felloe Depicting Tenon and Method of Wedging Which will Split the Felloe

axle, while in the plane of the wheel the minor diameter of the elliptical section is 1 3/16 in., which dimension prevails in this plane from point A, B, out to the felloe. In some types of spokes the section at the engagement of the felloe is round, and reduced gradually to the section at A, B. Fig. 331 shows a section of the hub of another type of wheel, in which the radial depth of flanging is 2¼ in., and the axle thickness of the wood is 2⅛ in. This wheel may be used on a 60 H. P. car, and will serve as a safe example of depth of flanging, as well as a guide in fixing the shear section of the spokes for stresses induced, when cars of great power skid, provided the wheel is not dished. Fig. 333 shows the same spoke at its engagement with the felloe, indicating the manner in which the spoke is wedged into the felloe.

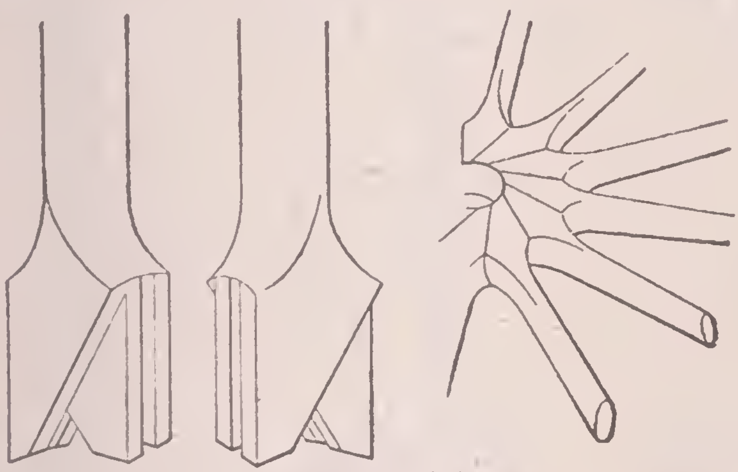


Fig. 334
Schwarz Wheel Showing Miter Joints

Figure 334 shows the Schwarz type of wheel, indicating the method of overlapping the miter, thus making it possible to true up the wood work independent of the hub. Fig. 335 shows a section of the hub, spoke and felloe of a dished wheel, and it will be seen that the felloe is not in the plane of the miter, and the dish of the wheel is outward. When a car is running at a comparatively high speed rounding a curve, the outer wheels are stressed in such a manner that the tendency is to set a dish in them exactly opposite to the dish given by the wheel maker.

The shorter the spokes are, the greater will the dishing have to be in order to insure that the spokes will be enough longer than the radial

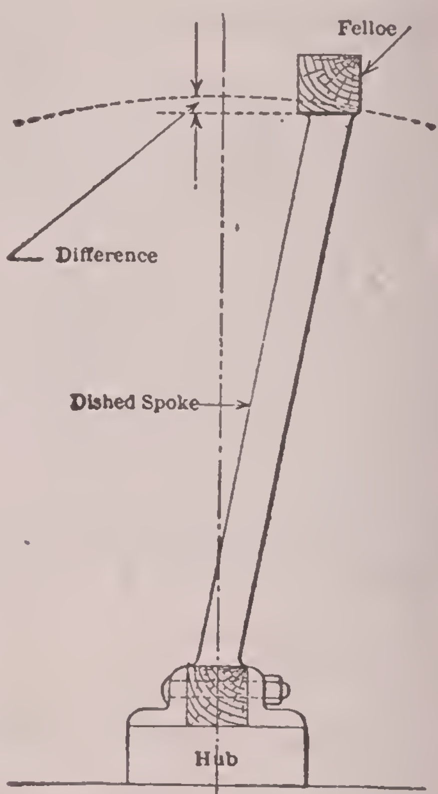


Fig. 335
Section of a Wheel Showing the Dish, Which Has Strength to Resist Skidding and Lateral Stresses

distance from the hub end of the spokes to the bearing against the felloe, to serve as members in compression, and the rim on the felloe will have to do the work. As the cut shows, the excess length of spokes marked "difference," represents the versed sine of the angle of the spokes.

Wheel Rim Sizes and Types. In Figure 336 are shown the sections of the three standard wheel rims which are designed to accommodate the three types of pneumatic tire bases. At the left is the plain clincher rim which is made in one piece and over which the tire base is forced into place. The plain clincher tire for use with this rim is made with its base soft enough to allow the necessary distension in applying.

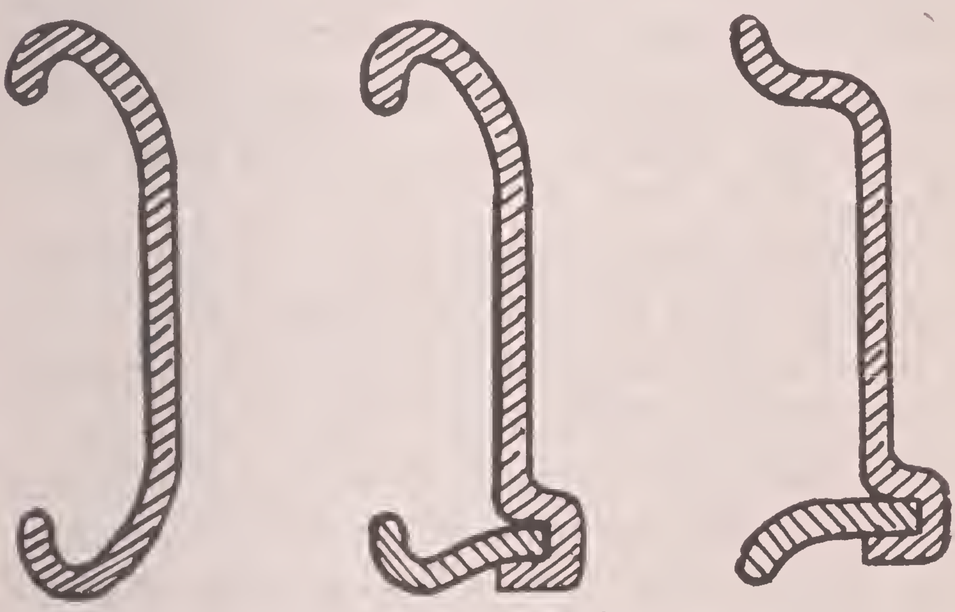


Fig. 336
S. A. E. Standard Rim Sections

In the center is shown the quick detachable clincher rim, often abbreviated "Q. D. Clincher," and which is designed to take a tire having a non-flexible base by the removal of the detachable ring from one side of the rim. At the right is shown the rim used with straight side tires which is similar in construction to that for the quick detachable clincher with the exception of the shape of the flanges which are suited to the tire base.

Wire Wheels. The development of the wire wheel has been very rapid during recent years. The invention of the wire wheel created a radical change in the method of load carrying, due to the fact that, instead of the compressive strain brought to bear upon a few spokes underneath the axle, as is the case with the ordinary type of wheel, there is a tensional stress on a large number of wire spokes, and the weight is thus held in suspension by the wire wheel with its steel rim and steel wire spokes.

Although the pneumatic tire is a great absorber of jolts, if the wheel strike an obstruction the shock of which is beyond the capacity of the tire to absorb, and if the wheel is fitted with rigid spokes, this shock is passed directly to the axle and from thence to the car springs, and unless these are equipped with efficient shock absorbers, the passengers are sure to feel the effects of rough riding. On the other hand the spokes of the wire wheel all act as a complex yet effective shock absorber, and in this way tend to reduce in a large measure the annoying effects of these vibrations. Another advantage in connection with the use of wire wheels is that the wheel itself, owing to its construction and the nature of the material, acts as an effective tire cooler, which is not the case with the wooden wheel, for the reason that the spokes of the latter do not tend to radiate the heat generated in the tire while running, consequently this heat must radiate from the tire and rim and the process is a very slow and ineffective one. Regarding the two important features of durability and lightness of weight, experience has demonstrated that the wire wheel compares favorably with the wooden wheel. It is claimed that the lightness of the wire wheel is an important factor in reducing the tendency to gyroscopic action, which is always present in wheels running at high speeds.

The number of spokes in each wheel and method of their attachment to the hub and the rim vary according to the ideas of the designers. In some types of wire wheels the rim only is demountable, while other types have all the functions of a demountable rim and a demountable wheel. The Lindsay twin wire wheel (a semi-sectional view of which is shown in Figure 337) is a notable example of the latter type. The component parts of the Lindsay wheel are assembled into two complete self-contained sections or units, hence its name. There are eighty spokes that connect the rim parts and hub parts together. The wheel as a whole is mounted on the inner fixed hub and interlocks with it, also interlocking with the web of the brake drum. The form of structure gives two rows of spokes laced in each side of the wheel, thereby taking care of the side thrust from either side equally. The tire rim is mounted between the two conical felloe rims of the two wheel sections and is held in place by the rim bolts, thus making it secure. Since the tire rim is secured in place between

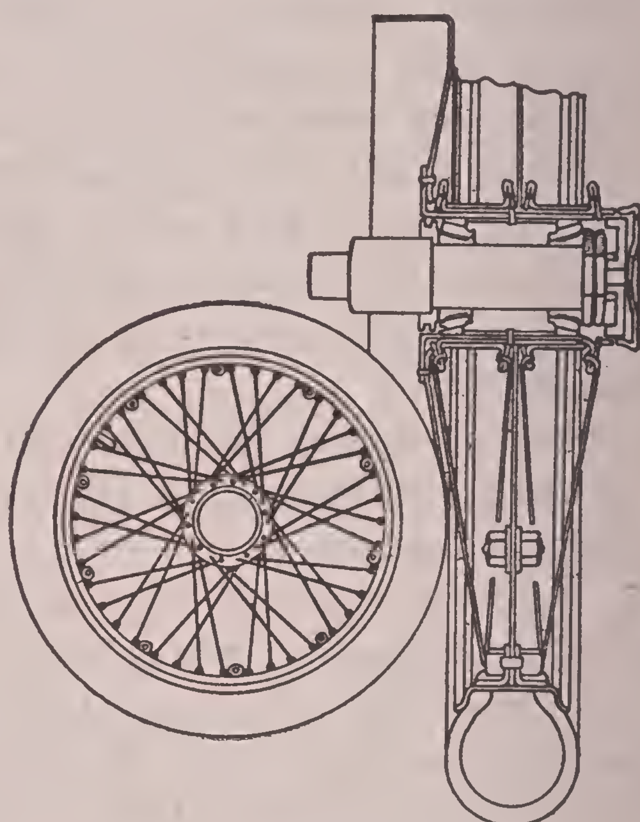


Fig. 337
Lindsay Twin Wire Wheel

the two wheel rims by means of rim bolts it is evident that both wheel and tire rims will expand and contract together. By removing the rim bolts with a wrench and taking off the hub dust cap, the outer twin wheel can be dismounted, leaving the inner wheel intact, thereby releasing the tire.

Another type of wire wheel is the Spranger, a view of which is shown in Figure 338. In this wheel there are 48 spokes interlaced in a simple cross system and equipped with a demountable rim, which like the demountable

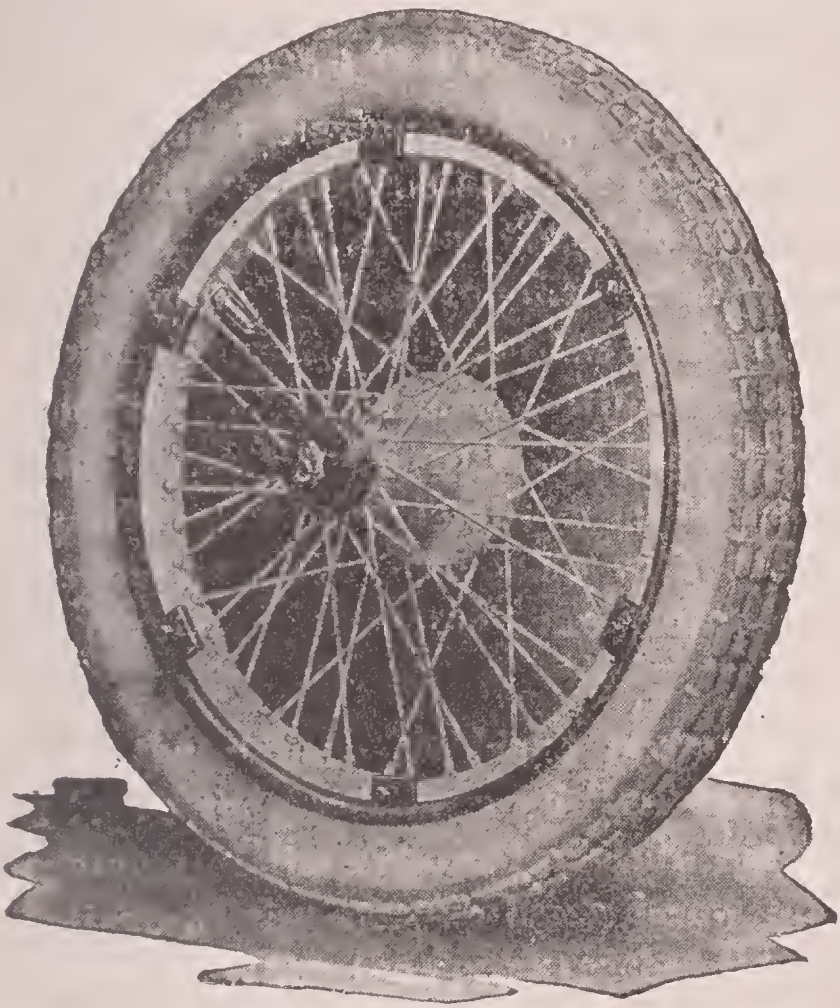


Fig. 338
Spranger Wire Wheel

rim on a wooden wheel, can be removed for the changing of the tire. The Spranger wheel itself is not demountable, and when installing these wheels on his car the owner obtains a complete new set of bearings, brake drums, and hub caps. This type of wheel has recently come into extensive use on the Ford and Chevrolet cars. In the construction of the Spranger wire wheel a special type of channel is used. This channel is of structural steel, and is 1½ inches in width by ¾ inch in depth, and into it the spokes are laced. The method of locking the rim to the wheel is as follows: each rim has six steel blocks securely riveted to it, which prevent the rim from rising or losing position, while at the same time there is no wedging action.

In Figure 339 is presented a view of the Houk wire wheel, made by the Wire Wheel Corporation of America.

Each wheel contains 72 steel wire spokes, each of which, before the wheel is assembled, is subjected to a test and must withstand a strain of 3,200 pounds. The spokes are arranged in triple rows as will be seen by the illustration, the triple lacing thus providing a set of spokes to take up the strain from any direction.

One end of each wire spoke is securely riveted to the rim, while the other end is secured to the hub in its proper location also by riveting. It is claimed that the interlacing of the spokes is of such a nature that three-fourths of them are continuously in use, supporting the load by suspension. In case of tire trouble, such as a puncture or blowout, the wheel can be removed in a few minutes by merely jacking up the car and unscrewing one nut. The wheel with the damaged tire can then be replaced by the extra wheel with a good tire.

Mention has already been made of the increased efficiency of the wire wheel as a tire

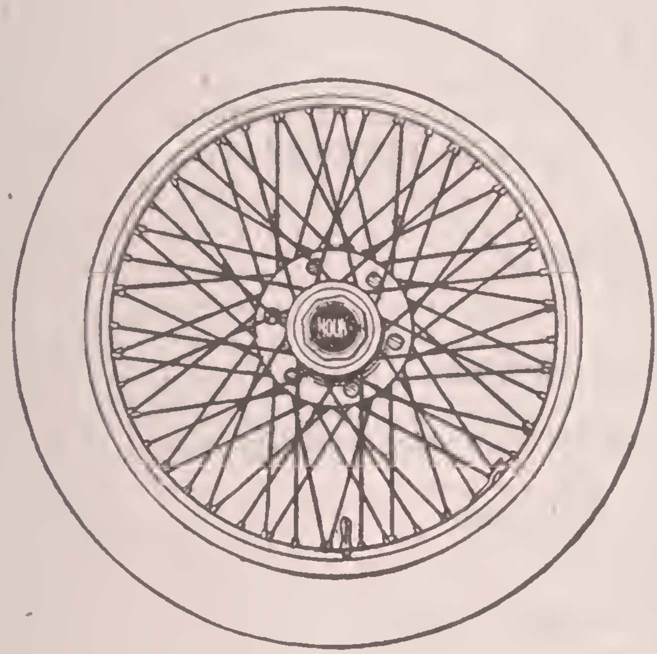


Fig. 339
Houk Wire Wheel

cooler, as compared with the wooden wheel. Another point in favor of wire wheels is the small area of spoke surface to be acted upon by the atmosphere in its resistance to the movement of the car. This resistance is always present, and the greater the area of the surface that is presented by a moving body for the atmospheric pressure to act upon, the greater will be the resistance tending to retard that movement.

INDEX

A

PAGE
Acid, battery 7
Accelerator 7
Accumulator 8
Acetylene gas 317
Adjustment, bearing 86
ignition. See name of system.
Advance, automatic ignition..................394, 438
Air 8
cooling 228
resistance of 8
starter 546
Alcohol 10, 316
cooling solutions 239
wood 317
Allis-Chalmers electrical equipment.............. 550
Alloys 14
Alternating current 16
Aluminum 16
solder 17
Ammeter, construction of.................................. 19
use of 18
Ampere 23
-hour 23
Annealing 23
Anti-freeze mixtures 239
Armature, dynamo 24, 25
Assembling 511
Atwater Kent ignition.................................. 366
wiring 355
Autolite electrical equipment.................................. 556
Automatic advance 394, 438
Automobile 26
Axle, front 27
full-floating 34
rear 33
rear, internal gear 38
rear, worm driven 44
semi-floating 33
three-quarter floating 33, 37

B

PAGE

Ball bearings 74
Ball-socket joints 473
Band clutch 209
Battery connections 53
    dry 51
    storage 55, 67
    storage, care of 58, 68, 72
    storage, charging 65
    storage, testing 65, 69
Bearing, ball 74
    ball, capacity of 73
    ball, lubrication 79
    metals 14
    plain 82
    roller 89
Bendix drive 93
Benzine 316
Berline 102
Bijur electrical equipment 559
Bodies 96
Bosch electrical equipment 564
    magneto 408, 410, 414, 425, 464
Brakes 105
    lining for 109
    use of 258
Brass 15
Brazing 115
Bronze 15

C

Cabriolet 104
Camshaft, engine 282
Carbon deposit, removal of.......................... 118
Carburetion (see also Fuels, Fuel Mixtures and Fuel Feed).
Carburetor, action of.......................... 121
    alcohol 13
    fuel flow in.......................... 336
    Holly 132
    inlet manifold 284
    kerosene 317
    Kingston 138
    Rayfield 140

PAGE

Schebler 147
Stromberg 152
Zenith 168
Care and repair of cars 511
Cell, dry 51
storage 55
Centrifugal pump 234
Chain, tire 180
Change speed gearing 181
Charging, storage battery 65
Chassis 207, 531
Chauffeur 207
Clearance, plain bearing 88
Close coupled body 100
Clutch, action of 207
band 209
cone 210
disc 214
plate 216
trouble 217
Coil, induction 351, 472
Commutator, ignition 361
Compressed air starter 546
Compression 221
Condenser, ignition 223
Conductors, electrical and heat 227
Cone clutch 210
Connecticut ignition 376
wiring 350
Cooling 228
anti-freeze mixtures for 239
water pump for 234
Coupe 103
Coupling, Oldham 246
Cut-out, electric. See name of system.
muffler 501
Current, alternating and direct 16
secondary 531

D

Delco electrical equipment 566
ignition 381
Differential 247
bevel gear 249
spur gear 252

PAGE
Disc clutch 214
  valves 664
Distributor 362
Dixie magneto 425
Double ignition 405
Drive, Bendix 93
  bevel gear 33
  chain 175
  friction 182
  internal gear 38
  planetary 190
  shaft 532
  sliding gear 181
  worm gear 44
Driving, automobile 256
Dry battery 51
Dual ignition 405
Dynamometer 267
Dynamo armature 24, 25
Dynamo, electric lighting. See name of system.
Dyneto electrical equipment 588

E

Eisemann magneto 430, 465
Electricity 267
Electric gear shift 493
Electrolyte, battery 7
  gravity of 538
Electromotive force 267
Engine, automobile (see also valves)..................... 268
  compression in 221
  eight and twelve cylinder..................... 301
  flywheel 281
  four cycle 289
  horsepower of 342
  pistons 277
  sliding sleeve 296
  two cycle 291
Equalizer, brake 112
Exhaust, smoky 312
Expansion of mixture 312

F

Fires, extinguishing 338
Fluxes, soldering 528

PAGE

Flywheel, engine 281
Ford magneto 441
  lubrication 490
  transmission 190
Four cycle engine 289
Frames 313
Friction 314
  transmission 182
Front axle 27
Fuel (see also Alcohol, Gasoline, Kerosene)..130, 315
  alcohol as a.......... 10
  feed, vacuum 327
  kerosene as a 478
  mixture 318

G

Gases, expansion of 336
Gasoline 316, 336
  air mixtures 318
  viscosity of 336
Gearing, change speed.......... 181
  horsepower transmitted by.......... 338
  planetary 340
Generators, electric lighting. See name of system.
Gravity, specific 538
Gray and Davis electrical equipment.......... 591

H

Heat, unit of 657
Heinze magneto wiring 466
Holly carburetor 132
Horsepower 341
  electrical 345
  required 8

I

Ignition (see also Magneto).......... 347
  Atwater Kent 366
  condenser 223
  Connecticut 376
  control 261
  Delco 381
  distributor 363
  double 405

PAGE
dual 405
Heinze 466
Kingston 466
magnetic type 402
Mea 465
Remy battery 388
Remy magneto 451, 468
Simms magneto 469
single 404
Splitdorf 458, 471
timing 363
transformer coil 405
trouble 364
types of 404
Westinghouse 392
Induction coil 351, 472
Inductor magneto 425, 448
Inertia 472
Insulators 227, 472
Internal gear rear axle 38

J

Joints, ball and socket 473
knuckle 474
universal 474

K

Kerosene 317
as a fuel 478
Kingston carburetor 138
magneto 466
Knight engine 296
Knocking 479
Knuckle, steering 31

L

Lamps, electric 481
Landaulet 102
Lighting batteries 103
Lighting, electric (see starters) 546
Limousine 101
Lubrication (see also Oil) 482, 485, 490
gear and clutch 490
gear case and axle 492

M

PAGE
Magnetic gear shift 493
 transmission 201
Magnetism 498
Magneto, action of.............................. 402
 Bosch 408, 421, 464
 care 418
 Dixie 425
 Eisemann 430, 465
 Ford 441
 Heinze 466
 inductor 448
 Kingston 466
 Mea 443, 465
 removal and replacement 405
 Remy 448, 468
 Simms 453, 469
 Splitdorf 456, 471
Manifold, inlet 284
Mea magneto 443, 465
Metal, strength of.............................. 645
Mixture, fuel (see also fuel).............................. 318
Motor, automobile (see engine).............................. 268
 spirit 317
Muffler, exhaust 499

N

North East electrical equipment.............................. 601

O

Oil, (see also Lubrication).............................. 482
 tests of 485, 488
Oldham coupling 246
Overhauling 511
Owen magnetic transmission 201
Oxy-acetylene welding 680

P

Packing, materials for 502
Picric acid 503
Piston, engine 274

PAGE
Plain bearings 82
Planetary gearing 340
transmission 187
Plate clutch 216
Plugs, spark 533, 537
Polarity 503
Porcelain 504
Pounding, causes of 504
Preignition 532
causes of 505
Pump, water 234

R

Radiator—see Cooling.
Rayfield carburetor 140
Rear axle 33
Regulator, current, Allis-Chalmers 552
Bijur 559
Bosch 565
Delco 567, 576, 581, 585
Gray and Davis 592, 596
North East 601
Remy 604, 607
Rushmore 612
Simms-Huff 613
Splitdorf-Apelco 615
U. S. L. 621
Wagner 624
Westinghouse 627, 629
Remy electrical equipment 602
ignition 388
magneto 448, 451, 467, 468
wiring 350
Repair work 511
Resistance, electrical 227
Rheostat 531
Rim, wheel 689
Rings, piston 280
Roadster 101
Roller bearings 89
Rotary valves 662
Runabout 101
Running gear 531
Rushmore electrical equipment 609

S

	Page
Sedan	102
Shop work	511
Simms-Huff electrical equipment	612
Simms magneto	453, 469
Single ignition	404
Skidding	260
Sleeve valves	660
Sliding gear transmission	192
sleeve engine	296
Solder, aluminum	17
Soldering	527, 532
Spark plugs	533
Specific gravity	538
Splitdorf-Apelco electrical equipment	614
Splitdorf magneto	456, 458, 470, 471
Springs, automobile	539
care of	543
dimensions of	541
eye and clip sizes	544
leaf points of	545
testing of	542
Sprockets	177
Starter, air	546
engine	546
Allis-Chalmers	550
Autolite	556
Bijur	559
Bosch	564
Delco	566
Dyneto	588
Gray and Davis	591
North East	601
Remy	602
Rushmore	609
Simms-Huff	612
Splitdorf-Apelco	614
U. S. L.	618
Wagner	622
Westinghouse	627
Starting motor drive, Bendix	93
Steel	637
Steering gear	638
knuckle	31
Storage battery	55, 67

PAGE
Strength of metal 645
Stromberg carburetor 152

T

Tar benzol 316
Thermo-syphon cooling 232
Threads, screw 647
Timer, ignition 361
Timing of valves 668
  of ignition (see also name of System) 363
Tire care and repair 647
  vulcanizing 651
Tools, automobile 513
Torpedo body 100
Torsion rod 654
Touring car 100
Town car 103
Traction of driving wheels 654
Transformer coil ignition 405
Transmission (see also Change Speed) 181
  Ford 190
  friction 182
  gearless 200
  gearing 338
  magnetic 201
  planetary 187
  sliding gear 192
Trouble, clutch 217
  cooling 236, 245
  ignition 364
  knocking 479
  pounding 504
  preignition 505
  starting and lighting 554
  steering gear 642
  storage battery 59
Two cycle engine 291

U

Unit of heat 657
Universal joint 474
U. S. L. electrical equipment 618

V

Vacuum fuel feed 327

PAGE
Valves, automobile engine 658
clearance of 665
disc. 664
grinding of 675
lead of 668
location of 658
rotary 662
sleeve 296, 660
tappet adjustment of 665
timing of 668
Vulcanizing 651

W

Wagner electrical equipment 622
Water cooling 232
Watt-hour 680
Welding, oxy-acetylene 680
Westinghouse electrical equipment.................... 627
ignition 392
Wheels, wood 682
wire 690
Wiring, Allis-Chalmers 553
Atwater Kent 355
Bijur 561, 562
Bosch 410, 414, 425, 464
Connecticut 350
Delco 567, 568, 577
Eisemann 465
Gray & Davis 593, 597
Heinze 466
Kingston 466
Mea 465
Remy 350, 605
Remy magneto 451, 452, 467, 468
Simms magneto 469
Splitdorf-Apelco 616
Splitdorf magneto....................458, 459, 470, 471
U. S. L. 620, 623
Westinghouse 630, 631, 635
Westinghouse ignition 399
Worn driven rear axle 44

Z

Zenith carburetor 168